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Climate change instruction in higher education: Pre-service teachers' engagement in an interdisciplinary pop-up learning community

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Climate Change Instruction in Higher Education: Pre-Service Teachers' Engagement in an Interdisciplinary Pop-Up Learning Community

by

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Dedication

I would like to dedicate this thesis to my husband, who has been my constant supporter through this program. Thank you for your encouragement, patience, and kindness. I am so grateful for you and all you have done to make completing this degree possible.

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I would like to share my gratitude to all involved in the completion of this project. I would first like to thank my participants: students from CHEM 406/407, for their participation in individual interviews; students from CHEM 101, for their participation in focus group interviews; students who participated in the Pop-Up Learning Community event; and those who participated in my pilot study. I would like to thank my research advisor, Dr. Amy Flanagan Johnson, for her guidance throughout this study. I would also like to thank my committee members, Dr. Harriet Lindsay and Dr. W. John Koolage, for their feedback and support of this research. My appreciation goes to Victoria Hill, fellow graduate student, for her encouragement and collaboration. I would like to thank the EMU Chemistry Department for their support. I would like to thank Dr. Grigoris Argeros for assistance with statistical analysis on survey data and Dr. Katherine Ryker for her work with statistical analysis of confidence data. I would like to thank all involved in the planning and organization of the Pop-Up Learning Community event, whose names are listed in Appendix A. Thank you to the EMU General Education Program and the EMU Women in Philanthropy for making the Pop-Up Learning Community event possible through their funding and support.

Abstract

An interdisciplinary pop-up learning community (PLC) allowed students from various disciplines with different levels of content knowledge to discuss their perspectives and beliefs on climate change. The impact of this event on students was gauged by a survey from the Yale Project on Climate Change Communication. Furthermore, this project focuses on pre-service teachers who participated in the PLC. In order to investigate how pre-service teachers understand climate change and how they may or may not integrate these issues into their own instruction, individual interviews were conducted prior to and after the PLC to determine if the event had an impact on the pre-service teachers' beliefs on climate change. After attending the PLC, students now realize that climate change is an interdisciplinary topic and they can apply their general education skills when addressing climate change arguments. Pre-service teachers reflected on how they would bring environmental awareness into their own classrooms.

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Chapter 1: Introduction

Review of Literature

In recent years, climate change has been in the foreground of social and political discussions. Scientific consensus on climate change has been questioned and the consequences of anthropogenic climate change have remained unaddressed both by policymakers and the public alike (Hamilton & Stampone, 2013; Pasek, 2018). In the mid-1990s, a National-Science-Foundation-funded study involving three higher education institutions began integrating environmental science into chemistry instruction for non-science majors in order to bring environmental and social topics into the undergraduate science curriculum (Swan & Spiro, 1995). Nevertheless, climate change education remains absent in many university curricula across the disciplines. The knowledge that students do possess about climate change primarily comes from the media, the Internet, and educators (McBean & Hengeveld, 2000). Educators cannot control what is said in the media or on the internet, but we can control how we approach the topic of climate change in our classrooms. Students enter college with misconceptions about climate change and environmental issues, which have been molded by preconceived notions influenced by personal beliefs. Due to the presence of climate change topics in the public sphere, students of all academic majors benefit from the integration of environmental education into the curriculum. To better understand environmental attitudes of the general undergraduate population, student climate change awareness and knowledge must be evaluated across academic disciplines (Wachholz et al., 2014).

This evaluation begins with studies narrower in scope. A comparison between the climate change knowledge of STEM (Science, Technology, Engineering, and Mathematics) and non-STEM majors was accomplished through quantitative assessment before and after completion of

an earth science course, with a focus on scientific conceptual knowledge and statistical analysis of the resulting data (Aksit et al., 2018). Aksit and colleagues (2018) built off of previous studies in environmental educational research, but the novelty is apparent in the instrument used to document student content knowledge of climate change. Student assessment encompasses environmental content knowledge; risk perception of the consequences of climate change; and data regarding demographics, worldview, personal values, and political beliefs (Aksit et al., 2018). Students were assessed before and after completion of an earth science course, with a focus on scientific conceptual knowledge and statistical analysis of the resulting data (Aksit et al., 2018). The study revealed that there is an increase in risk perception and climate change knowledge after instruction for students with STEM and non-STEM majors alike (Aksit et al., 2018). Contrary to previous studies, they discovered that political views, ethnicity, and overall worldview may not have a significant impact on student perceptions of climate change (Aksit et al., 2018). This study emphasized incorporation of climate change instruction into the curriculum and delivered statistically significant results, showing an increase in content knowledge and risk perception after instruction (Aksit et al., 2018). They produced quantitative results to support their findings, compared to the wealth of qualitative research in this area.

STEM and non-STEM students may have different levels of content knowledge based on exposure to environmental instruction, a reality that comes into focus through investigation between academic disciplines (Lang, 2011). Because college students tend to be more environmentally conscious as a group, Lang (2011) emphasizes the importance of assessing the attitudes of students from different fields of study toward climate change to determine which majors have a higher or lower concern for the environment. The purpose of this research is to determine what relationship exists between academic major and environmental attitudes and

beliefs. Due to findings from previous studies involving the influence of gender and political orientations on environmental beliefs, Lang (2011) aims to determine if a higher percentage of women, political liberals, and financially secure students in an academic major has an impact on the environmental attitudes of students in that major as a whole. His study involved incoming university students before the start of their first semester, which indicates that all results are based on prior beliefs and attitudes toward environmental issues without the influence of college instruction (Lang, 2011). Controlling for gender, socioeconomic status, and political affiliation, Lang (2011) found that incoming business students have lower measures of environmentalism than students of other disciplines, which is consistent with prior studies. Education majors scored higher than all other majors in intent to recycle and support of campus environmental initiatives (Lang, 2011). This research emphasizes that a relationship between academic major and environmental concern exists and must be considered when integrating environmental issues into the curriculum. Non-STEM students are less likely to encounter climate change topics in their fields of study. Students across majors will interact with environmental issues differently. In addition to a lack of climate change instruction, personal beliefs influence the academic paths students choose as they enter college; thus, students decide their course of study based on what aligns with their worldview (Lang, 2011). Because of this, the integration of environmental topics into courses across the disciplines is vital in order to reach students who have minimal knowledge of climate change and its consequences.

Lee (2012) and coworkers found that pre-service teachers were influenced by morals and personal values when responding to socioscientific issues, such as climate change. Nevertheless, there are still concerns with the level of preparation pre-service teachers have related to climate change instruction as they enter their own classrooms. One study found that high school students

and pre-service teachers at the end of their academic experiences were equally under-informed about phenomena, such as climate change (Boon, 2010). This means that secondary teachers could enter their classrooms with the same level of climate change knowledge as their own students. Thus, we must also focus on teacher preparation, especially for secondary pre-service teachers who specialize in the sciences.

Climate change education at the university level is lacking, evidenced by the examination of student attitudes and behaviors about climate change, and concern for its effects (Wachholz et al., 2014). Wachholz and colleagues (2014) examined the attitudes of undergraduate students toward climate change through a deep look into student understanding of climate science, the level to which students are concerned about the consequences of climate change, and student opinions regarding the integration of climate change education into the university curriculum. This study is novel in its goal of comparing student attitudes and behaviors about climate change, and concern for its effects, across the academic disciplines (Wachholz et al., 2014). The recent study also provides student evaluations of current climate change educational standards in place in the classroom and on the university's campus. (Wachholz et al., 2014). This research provides insight into the lack of climate change education in the college curriculum. The students involved in the study held many misconceptions about the causes and consequences of global climate change (Wachholz et al., 2014). These results allow educators to identify weak points in course structures across the disciplines. In turn, students were able to evaluate the university's current climate change curriculum. By critiquing the current curriculum, students were given the opportunity to interact with chemical and environmental knowledge in a new way and offer their feedback to improve climate change education in the classroom and beyond. By involving students in the curriculum development process, faculty members were then better able to

understand and address the needs of students (Wachholz et al., 2014). Student evaluation of climate change education in the classroom can provide insight into gaps in the curriculum between departments, especially in courses that do not traditionally discuss scientific topics. Involving students in curriculum changes not only gives them a voice in their academic experience but also allows them to make global climate change a priority in higher education.

Due to the absence of global issues such as climate change in the majority of college courses, educators must be effective in their delivery of environmental instruction. Persuasive information sources cause students to change their attitudes toward climate change and influence their inclination to act against the effects of climate change (Sinatra et al., 2012). Sinatra and colleagues (2012) investigated the impact a persuasive text on human-induced climate change had on college students' attitudes toward climate change and their willingness to alter their own behavior to limit the consequences of climate change. Their research aimed to find the degree to which persuasive information sources cause students to change their attitudes toward climate change and their inclination to act against the effects of climate change (Sinatra et al., 2012). Unlike other studies, they included an image along with the persuasive text, as images have been shown to be influential in changing readers' attitudes or attention to the text's content (Sinatra et al., 2012; Messaris, 1997). They found that reading a persuasive text is an effective means of instruction in convincing college students of the imminent consequences of climate change (Sinatra et al., 2012). Thus, students were more inclined to change their behavior to lessen their own contribution to climate change after instruction. However, the study noted challenges preventing students from accepting scientific consensus of human-induced climate change, including misconceptions about climate science and commitment to personal beliefs (Sinatra et al., 2012).

Misconceptions stem from inaccurate information accepted as fact. Climate change and other global environmental issues are discussed in the media, often without the support of scientific evidence. Students thus develop beliefs on the basis of misinformation and opinions that are not rooted in factual evidence. Bråten (2011) led research whose purpose was to develop an understanding of how students evaluate the trustworthiness of information sources, such as newspapers and research magazines, on the topic of climate change. The students read multiple climate change information sources and were asked if they believed the information to be trustworthy based on different criteria, including content, personal opinion, and type of source (Bråten et al., 2011). The researchers also determined if students determined trustworthiness based on prior knowledge of climate science (Bråten et al., 2011). Students with low content knowledge were found to be more willing to trust sources with less credibility (Bråten et al., 2011). Because climate change has become an issue of great political controversy, it is important to understand what sources of information are trusted by readers and if this trust is well founded. This study was exploratory and thus granted a first look into how students judge information sources across different media.

The trustworthiness of sources and misinformation impact the public's beliefs on issues like climate change. Although these are issues supported by a great deal of evidence, misconceptions cause an inability to credit or discredit arguments in favor or against the existence of climate change. A common misconception involves equating weather to climate. As higher temperature averages become more frequent, short-term weather impacts views Americans hold regarding climate change: for example, agreement with anthropogenic climate change increases on unseasonably warm days (Hamilton & Stampone, 2013). Following studies that measure the impact of climate or weather on beliefs about climate change, Hamilton and

Stampone (2013) extend their analysis by focusing on whose beliefs, on the basis of political identification, change with the impact of weather. Americans were polled on unseasonably warm and unseasonably cold days to find a relationship between weather and agreement with scientific consensus on anthropogenic climate change (Hamilton & Stampone, 2013). Political party affiliation was an indicator of climate change belief and whether this climate change is caused by humans (Hamilton & Stampone, 2013). This study confirms that short-term weather impacts views Americans hold regarding climate change, as higher temperature averages become more common (Hamilton & Stampone, 2013). Hamilton and Stampone (2013) found that climate change beliefs held by Democrats and Republicans are not easily changed by temperature effects. However, among Independents, short-term temperature increases agreement with scientific consensus for anthropogenic climate change (Hamilton & Stampone, 2013). Thus, environmental and climate education may have a greater impact among Independent or undecided voters, as opposed to Democrat or Republican voters. Although warmer weather may cause wider acceptance of climate change, a correct understanding of climate should be encouraged and educators should emphasize how it differs from short-term weather.

The public, having obtained knowledge from untrustworthy sources, is at risk of forming opinions on environmental issues based on misinformation. Misinformation ultimately counteracts the effect that scientific consensus has on public opinion; thus, misinformation has just as much of an effect on public perception of the consequences of human-caused climate change as scientific evidence (van der Linden et al., 2017). Van der Linden and colleagues (2017) investigated how the public responds to consensus on a highly polarized, now political, issue such as human-caused climate change. Their research aimed to protect the public from incorrect information against expert consensus of climate change (van der Linden et al., 2017).

In addition to exploring inoculation of the public against misguided claims about climate change, the group investigated the impact of misinformation on the public's attitudes toward consensus (van der Linden et al., 2017). They engaged with this inoculation under the assumption that people have strong attitudes regarding climate change already in place (van der Linden et al., 2017). By communicating that there is scientific consensus that anthropogenic climate change exists, the public is more likely to perceive this consensus as fact (van der Linden et al., 2017). Van der Linden and coworkers (2017) also determined that misinformation ultimately counteracts the effect that scientific consensus has on public opinion; thus, misinformation has just as much of an effect on public perception of the consequences of human-caused climate change as scientific evidence. The group was able to establish a positive relationship between scientific consensus education and the public's response to climate change evidence.

Individuals reject scientific consensus on the basis of their personal beliefs despite being educated on scientific issues (Pasek, 2018). Pasek (2018) aimed to investigate the influence of motivated reasoning on the public's attitudes toward scientific consensus rather than ignorance. Politics and religion greatly impact the American public's ability to accept scientific consensus. Pasek (2018) explored how people respond to consensus on scientific issues and how their personal beliefs impact their willingness to disagree with scientific consensus or to go against pre-existing personal beliefs. His study found that people having opinions or personal beliefs not based on scientific evidence does not mean that they are ignorant of scientific evidence or consensus (Pasek, 2018). Individuals are able to reject scientific consensus on the basis of their personal beliefs despite being educated on scientific issues, which leads to a challenging conclusion: education on scientific consensus may not be enough to persuade the public on the validity of scientific claims and evidence. Nevertheless, university curricula can adapt to educate

students on the legitimacy of scientific consensus by incorporating socio-scientific issues into class discussion or assessment.

Purpose of the Study

Climate change and environmental education studies have highlighted the need for integration of environmental and socio-scientific topics into the university science curriculum. However, the current research indicates that a lack of climate change education exists across academic disciplines at the college level (Wachholz et al., 2014). Bringing climate change topics into classroom discussion allows students of all majors to interact with global issues that may not otherwise be taught in non-STEM fields. STEM and non-STEM students alike need to experience applying knowledge gained in courses to interpersonal dialogue on global issues. General education courses equip students with the skills necessary to discuss topics, such as climate change, competently and effectively; thus, students develop analytical skills in general education courses that can be directly applied to climate change discussions. The current literature lacks studies with a focus on interdisciplinary climate change dialogue among undergraduates. Students have been assessed across academic disciplines regarding climate change knowledge, but how they apply analytical skills and disciplinary knowledge to environmental topics has not yet been investigated (Wachholz et al., 2014).

In order to understand how undergraduates in general education courses use their disciplinary knowledge and skills in response to climate change arguments, a pop-up learning community (PLC) was developed to assess students' ability to analyze claims and evidence used in the discussion of global climate change. Students from various general education courses were present at the event, representing the chemistry, philosophy, communications, and physics departments.

Guiding Research Questions

In qualitative studies, guiding research questions serve to focus data collection on specific topics of interest (Miles et al., 2019). In the case of this study, we have chosen to examine the attitudes and perspectives that pre-service science teachers have on climate change education. Based on the literature review, education majors have a greater tendency toward expressing higher environmental concern and we wanted to explore how pre-service teachers would bring climate topics into their own classrooms (Lee, 2012). Furthermore, students in teacher preparation programs have been found to be under-informed about climate change and other environmental topics, which led us to an interest in pre-service teachers' comfort level and preparation in teaching about climate change (Boon, 2010). The general questions that have guided our research are as follows:

1. How do pre-service teachers understand climate change? What influences their understanding?

2. How do pre-service teachers plan to integrate climate change into their own instruction, if at all?

Chapter 2: Methods

Study Design

This study is centered around a PLC, with supplemental interviews to engage with pre-service teachers regarding their climate change belief and motivation to include climate change instruction in their future classrooms. Learning communities (LCs) offer students an opportunity to engage with students from other courses in an interdisciplinary setting (Love, 2012). LCs promote critical thinking and support diverse perspectives, focusing on student development and active involvement (Zhao & Kuh, 2004). LCs have also been found to improve student achievement and learning outcomes while gaining experience using collaborative learning strategies (Love, 2012; Zhao & Kuh, 2004). Participation in LCs has led to improved academic and social integration, which in turn increases student retention (Love, 2012). For these reasons, our event was conducted in the form of a learning community. However, it is also important to note the challenges that LCs pose, including student reluctance to participate and the logistical difficulties that come with faculty collaboration (Zhao & Kuh, 2004).

The PLC was inspired in part by Pop-Outs at Stanford's Hasso Plattner Institute of Design. Pop-Outs are led by a group of professionals from different disciplines and focus on interdisciplinary collaboration between students from different courses (Hasso Plattner Institute of Design, 2019).

The purpose of the PLC was to give students the opportunity to practice their general education skills and content knowledge in a new context. The event organizers wanted to learn more about how students engage with the topic of climate change through interdisciplinary discussions and faculty modeling. Students were given the opportunity to write and converse about climate change in an interactive setting. The aim of the event was not to persuade participants to change

their beliefs about climate change, as facts and climate data were not provided. However, students were assessed prior to and after the PLC on their climate change beliefs and attitudes. The supplemental interviews were conducted in order to learn more about how pre-service science teachers view climate change and its effects.

Pilot Study

The pilot study for individual student interviews took place in early Fall 2019. There were challenges in finding student participants because our initial pilot study population, BIOT 403, majorly overlapped with our study population, CHEM 406/407. I was able to conduct pilot study interviews with three students from the physics and biology departments. Because some of these students were not pre-service teachers, teaching-focused questions were geared toward outreach in their field. I asked each student the following questions during their individual interviews:

1. What does the term "climate change" mean to you?
2. What has influenced your definition of climate change? What sources have contributed to your understanding of climate change (e.g., social media, coursework, friends/family, etc.)?
3. How do you think climate change impacts our planet, if at all?
4. How do you think climate change impacts you personally, if at all?
5. What sources have influenced your thoughts on personal and global impacts of climate change?
6. How prepared do you feel to teach lessons/activities about climate change? What challenges do you foresee?

7. How will you integrate skills and content learned in your college courses as you design climate change lessons/activities for your students, if at all?

After conducting the pilot study, we decided to add a new question at the beginning of the interview about the student's comfort level discussing climate change topics to ensure that students felt comfortable answering the remainder of the interview questions. Additionally, two-part questions (Questions 2 and 6 listed above) were split to become separate questions to allow for students to focus on fully answering each component. The pilot study also served as practice for me, the interviewer, so that I was able to improve the manner in which I conducted the interviews. Consent was obtained prior to the interview and audio recordings were taken during the course of the interviews.

IRB and Ethics

An IRB proposal was submitted and accepted in Summer 2019. The IRB approval letter can be found in Appendix B. Students participated in interviews on a volunteer basis. All study participants received course credit for participating in the PLC. Participant consent was collected through a pre-PLC online survey. Interview consent was collected prior to the first individual and focus group interviews.

Study Population

Students representing general education courses in chemistry, philosophy, communications, and physics participated in the 2019 PLC ($N = 85$). Table 1 outlines the distribution of participants based on what discipline they represented at the PLC event. The majority of PLC participants (78.8%) represented general education courses in the chemistry and

philosophy departments. The remainder of participants came from general education communications and physics courses.

Table 1

Pop-Up Learning Community Participants by Represented Discipline

Represented Discipline	**Number of Participants (*N* = 85)**	**Percent of Total Participants**
Chemistry	34	40%
Philosophy	33	38.8%
Communications	10	11.8%
Physics	8	9.4%

I conducted individual interviews with pre-service elementary and secondary teachers from CHEM 406/407: The Nature of Science ($N = 13$). Elementary education majors accounted for 46% of the participants, and the remaining 54% were secondary education majors. Fifty-four percent of the participants identified as female and the remaining 46% identified as male. Students who participated in individual interviews were assigned gender-neutral pseudonyms to eliminate any bias in comparing interviews on the basis of gender. However, I refer to students throughout this document using their pseudonyms and preferred gender pronouns. I conducted focus group interviews with pre-service elementary teachers from CHEM 101: Chemistry for Elementary Teachers ($N = 13$). All focus group participants were elementary education majors. Seventy-seven percent of these participants identified as female and the remaining 23% identified as male.

Procedure

Students from CHEM 406/407 participated in the PLC event and took the Six Americas Super Short Survey (SASSY) prior to and after the event. During the event, these students interacted with climate change instructional materials and participated in interdisciplinary discussions. After the PLC, they submitted a reflection about their experience at the event. CHEM 406/407 students voluntarily participated in individual interviews, which were audio recorded in order to allow for transcription. They were interviewed before and after the PLC. Pilot study volunteers participated in one 30-minute individual interview. Students from CHEM 406/407 began participation with the pre-PLC 30-minute individual interview, continuing with the completion of a brief five-minute survey, the SASSY, participation in the two-hour PLC event, and submission of the post-PLC reflection, and concluded once they participated in the post-PLC 30-minute individual interview.

Survey (SASSY)

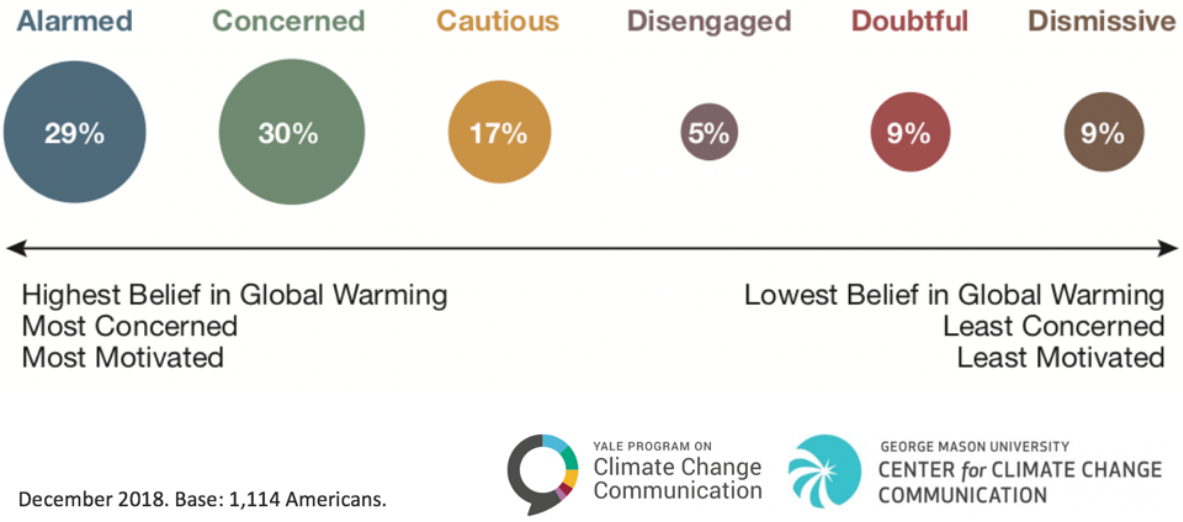
The Six Americas Super Short Survey (SASSY) is a questionnaire utilized by the Yale Project on Climate Change Communication (YPCCC; Chryst et al., 2018). The survey categorizes responses into "Six Americas," based on levels of climate change concern and perceptions. Each of the four questions has Likert-scale response options, which can be found in Appendix C. The survey questions are listed below:

1. How important is the issue of global warming to you personally?
2. How worried are you about global warming?
3. How much do you think global warming will harm you personally?
4. How much do you think global warming will harm future generations of people?

The YPCCC website contains a group scoring tool, which analyzes data collected from the SASSY to produce an output of the SASSY designation. The "Six Americas" designations are as follows, in order of highest climate change concern: Alarmed, Concerned, Cautious, Disengaged, Doubtful, and Dismissive. National estimates showing the distribution of "Six Americas" designations among Americans is shown in Figure 1.

Figure 1

SASSY Designations



Note. A ranking of the "Six Americas" designations that result from the SASSY, demonstrated using data collected by the Yale Program on Climate Change Communication in December 2018. From "Americans are Increasingly 'Alarmed' about Global Warming" by A. Gustafson, A. Leiserowitz, and E. Maibach, 2019, https://climatecommunication.yale.edu/publications/americans-are-increasingly-alarmed-about-global-warming/. Copyright 2019 by the Yale Program on Climate Change Communication.

The SASSY was included in a pre-PLC survey for all participants in the PLC. All PLC participants answered the survey questions again after the event.

Pop-Up Learning Community (PLC)

The PLC took place on October 25, 2019, with two 2-hour sessions taking place in the morning and afternoon. Students were grouped into diverse tables based on their SASSY designations and represented disciplines. The event began with the participants' written responses to a social media post created by the event's organizers, which can be found in Appendix D. Faculty representing the chemistry, philosophy, and communications departments modeled how they would use their own disciplinary skills to respond to artifacts relating to climate change. Among the artifacts were a video and tweets regarding the work of Greta Thunberg, a young climate change activist, and a U.S. congressman's religious defense of his own climate change beliefs. Participants were then given time to discuss the social media post at their tables, sharing their own thoughts and using the disciplinary skills modeled by faculty members. The participants were then given the opportunity to revise their written response to the social media post. After a presentation of moral relativism by a philosophy faculty member, students participated in a communications role-playing exercise entitled "Climate Change at the Dinner Table." Participants paired up and engaged in climate change conversations using the disciplinary skills previously modeled. At the close of the event, students assessed their confidence in speaking and writing about climate change and retook the pre-PLC survey, including the SASSY.

Reflections

After attending the PLC, participants were given one week to submit a reflection of their experience at the event with the following guiding questions:

1. What did you learn today?
2. How has participating in the PLC impacted your knowledge of and attitude toward climate change information and communicating it to others?
3. How can you envision applying the lessons learned today in future interactions with others, both in your personal and professional life?

Individual Interviews

I invited students from CHEM 406/407 who participated in the PLC to participate in individual interviews prior to and after the PLC event. Thirteen students participated in individual interviews prior to the PLC. Participation was split between six elementary and seven secondary pre-service science teachers. After making revisions based on the pilot study results, I asked the participants the following questions prior to the PLC event:

1. How comfortable do you feel talking about climate change and the issues surrounding climate change?
2. What does the term "climate change" mean to you?
3. What has influenced your definition of climate change?
4. What sources have contributed to your understanding of climate change (e.g., social media, coursework, friends/family, etc.)?
5. How do you think climate change impacts our planet, if at all?
6. How do you think climate change impacts you personally, if at all?
7. What sources have influenced your thoughts on personal and global impacts of climate change?
8. How prepared do you feel to teach lessons/activities about climate change?

9. What challenges do you foresee in teaching lessons/activities about climate change?
10. How will you integrate skills and content learned in your college courses as you design climate change lessons/activities for your students, if at all?

After students had submitted their PLC reflections, I invited the participants to participate in a post-PLC individual interview. Twelve students participated in interviews after attending the PLC, now with an even split between elementary and secondary education. The questions for the second interview are as follows:

1. How comfortable do you feel talking about climate change and the issues surrounding climate change?
2. Have any of your answers changed since your first interview (definition of climate change, global/personal impacts, sources that have influenced)?
3. How prepared do you feel to teach lessons/activities about climate change after attending the PLC?
4. Tell me about your experience at the PLC.
5. (If applicable:) What caused changes in your SASSY response?
6. Did any of the activities help you feel more confident speaking/writing?
7. What would you change about the PLC?

Focus Group Interviews

Focus group interviews were not originally included in our data collection plan. We decided to add these interviews after seeing the results of the SASSY and the distribution of SASSY designations. A revision to our IRB proposal that included this additional data source

was submitted and accepted in Fall 2019. We wanted to learn more about the perspectives and attitudes that pre-service teachers had depending on their SASSY designation, but all of the individual interview participants from CHEM 406/407 had SASSY designations of Alarmed or Concerned.

Due to the diversity in SASSY designations of this particular class, I invited pre-service elementary teachers from CHEM 101 to participate in focus group interviews after attending the PLC. These students were offered extra credit for their participation. I separated the student volunteers into homogeneous focus groups using their SASSY designations so that students might feel more comfortable sharing about their beliefs and experiences. Thirteen students participated in focus group interviews. Three of the focus groups had SASSY designations of Alarmed or Concerned. One focus group had SASSY designations of Cautious or Dismissive. The groups were asked the following questions:

1. What has influenced your climate change beliefs?
2. What would you need to see or what would need to happen in order for you to change your beliefs about climate change?

Analysis

The survey taken by participants prior to and after the PLC is the Six Americas Super Short Survey (SASSY) utilized by the Yale Program on Climate Change Communication. The results of this survey helped to gauge any change in climate change belief or concern as a result of the PLC event.

Responses to individual interviews, focus group interviews, and reflections were manually transcribed verbatim. All fillers and pauses were removed through intelligent transcription and all transcripts were subsequently qualitatively coded. I created well-defined, differentiated codes by identifying themes and patterns in the data set. I then compared and contrasted responses to ensure that the codes were representative of the data. Creating codes allows qualitative researchers to compare across data, identify relationships in the data, and find meaning through the experiences that have been shared by the participants (Basit, 2003). Qualitative codes represent the content of the data and help researchers detect patterns in the data during analysis, which in turn yields more trustworthy evidence (Saldaña, 2015). Triangulation of the data, or the use of multiple data sources, has been used in this study to ensure construction of valid themes throughout the data (Libarkin & Kurdziel, 2002). The codes that I constructed are described in each results and discussion chapter. The majority of reflections and interview responses contained more than one code, as shown in the data tables contained in each results chapter.

Chapter 3: Survey (SASSY) Results and Discussion

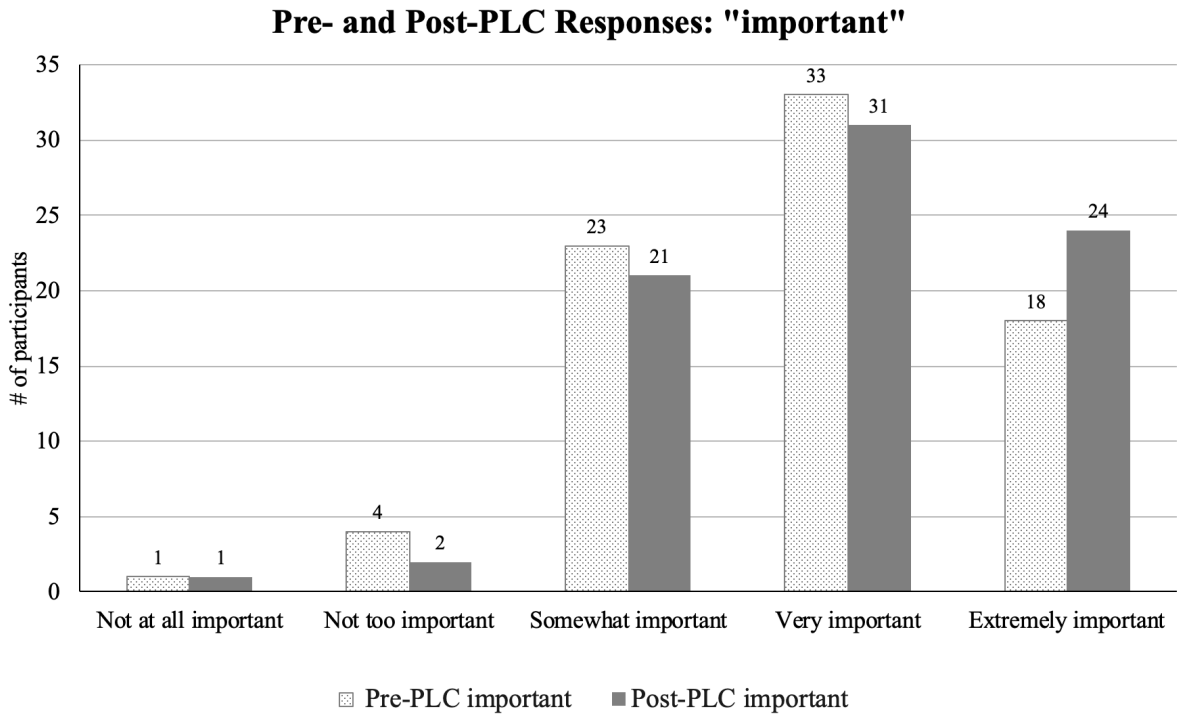
We collected SASSY responses from all PLC participants; however, only 79 PLC participants completed the survey both before and after the event. Thus, 79 responses were analyzed through the YPCCC's SASSY Group Scoring Tool. T-tests were computed to compare pre- and post-PLC responses to each survey question and the resulting SASSY designations. It was discovered that significant positive change occurred between pre- and post-PLC responses for the following question ("important") only:

- How important is the issue of global warming to you personally?

The pre-/post-PLC change for "important" had a p-value of .033, which is shown in Figure 2. All other survey question comparisons, shown in Figures 3, 4, and 5, and SASSY designations, shown in Figure 6, had p-values greater than .05 and were not statistically significant. To reiterate, the purpose of the PLC event was not to impact participants' climate change knowledge or beliefs, but rather to engage the participants in interdisciplinary discussions about climate change using their general education skills and content knowledge. However, we did find the significant change in the importance of climate change as shown in Figure 2.

Figure 2

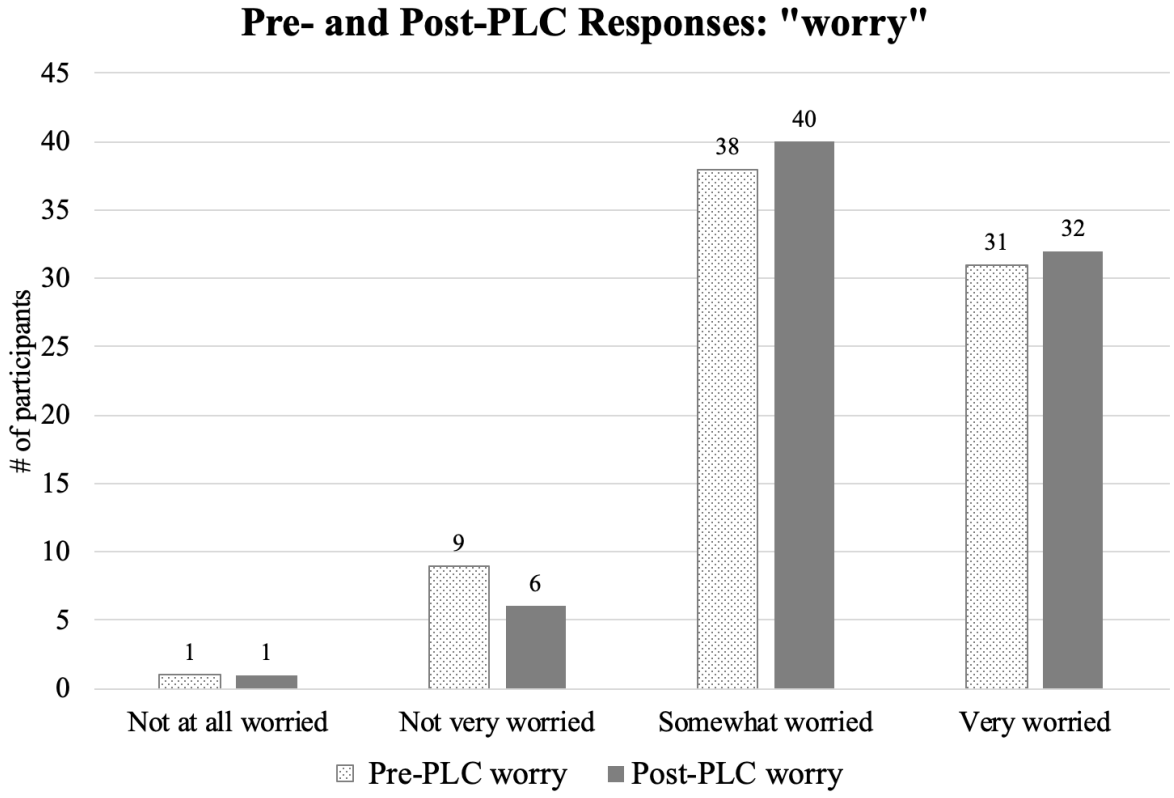
Pre-PLC and Post-PLC "Important"



Note. Comparison of responses to "How important is the issue of global warming to you personally?" prior to and after the PLC event's activities ($N = 79$).

Figure 3

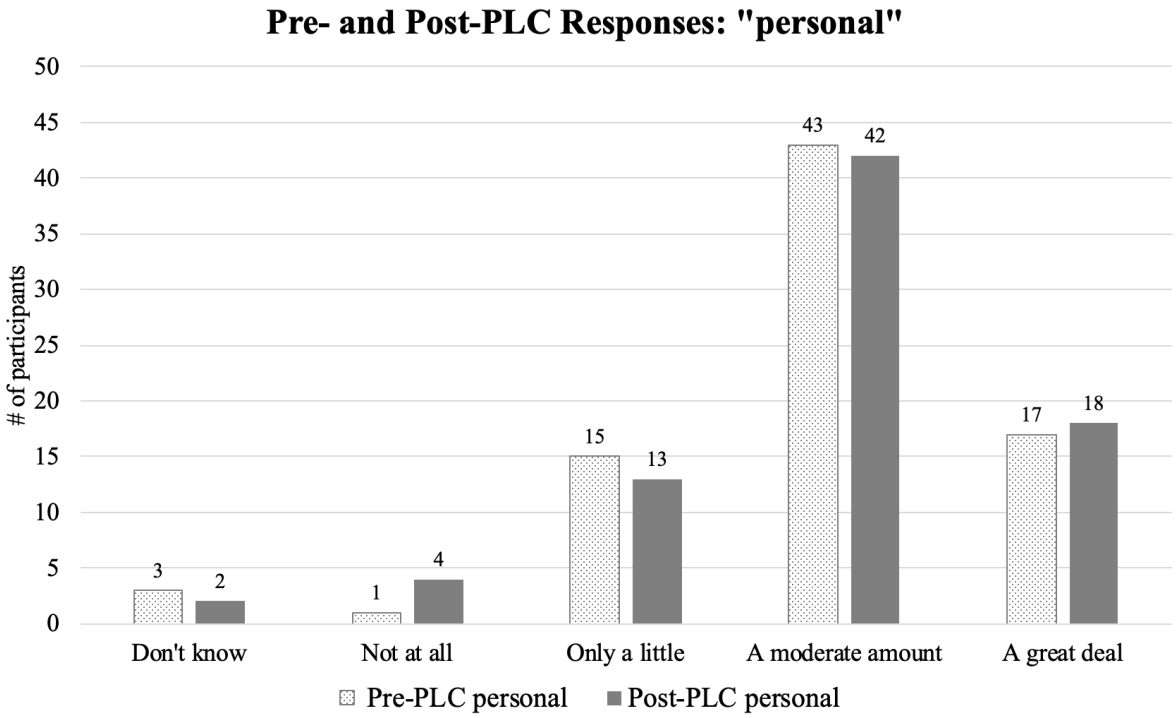
Pre-PLC and Post-PLC "Worry"



Note. Comparison of responses to "How worried are you about global warming?" prior to and after the PLC event's activities ($N = 79$).

Figure 4

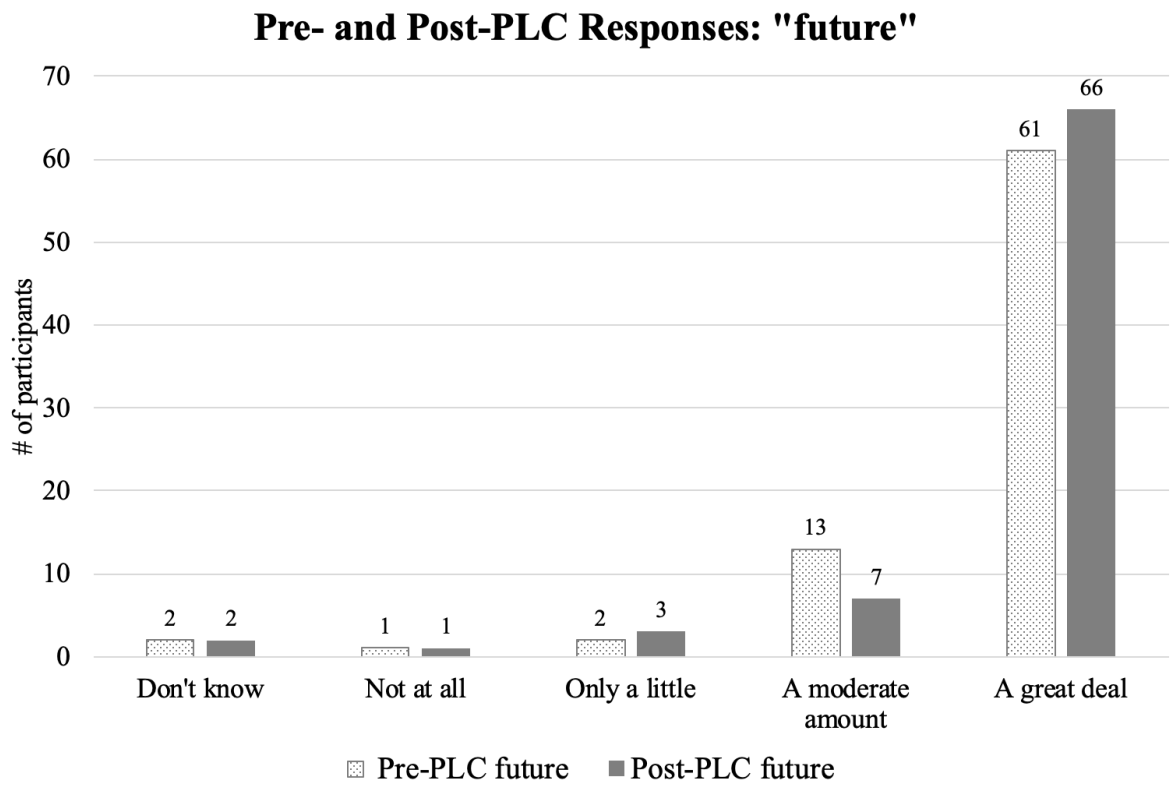
Pre-PLC and Post-PLC "Personal"



Note. Comparison of responses to "How much do you think global warming will harm you personally?" prior to and after the PLC event's activities ($N = 79$).

Figure 5

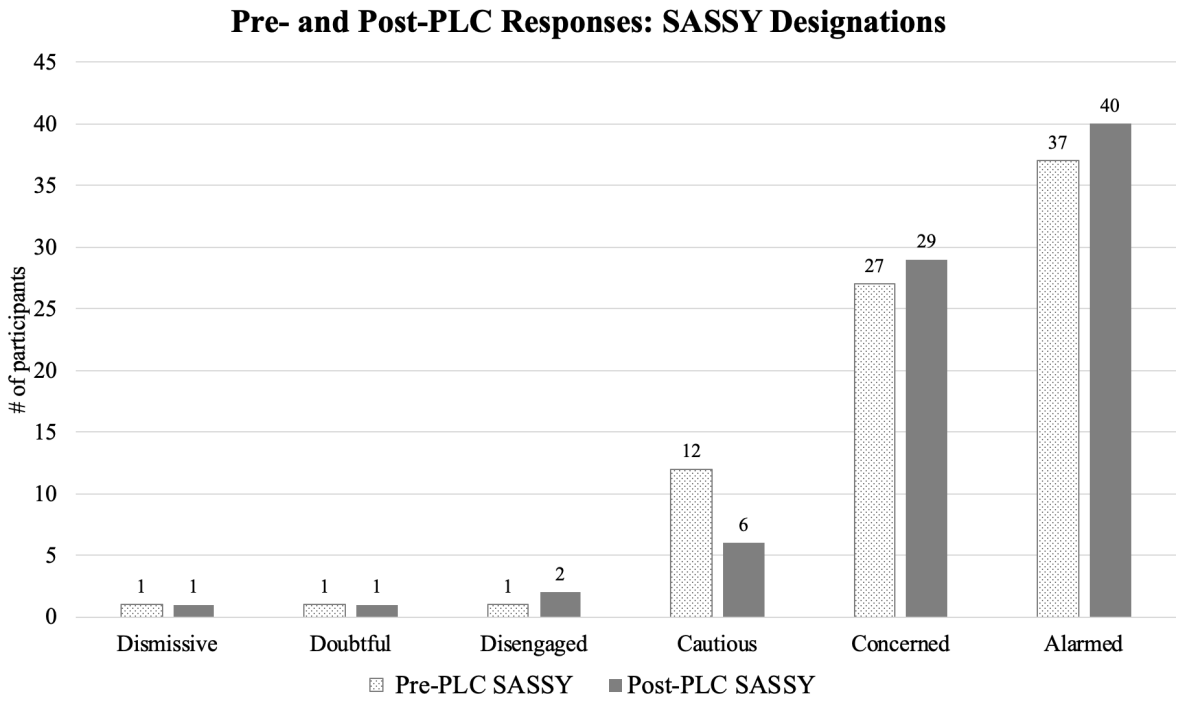
Pre-PLC and Post-PLC "Future"



Note. Comparison of responses to "How much do you think global warming will harm future generations of people?" prior to and after the PLC event's activities ($N = 79$).

Figure 6

Pre-PLC and Post-PLC "SASSY"



Note. Comparison of responses to SASSY designations prior to and after the PLC event's activities ($N = 79$).

Figures 7 and 8 compare the SASSY designations of our PLC participants prior to and after the event to national data collected by the Yale Program on Climate Change Communication (Gustafson et al., 2019). Our group of participants were more Alarmed and Concerned about climate change, both before and after participation in the PLC, than the national estimates of U.S. adults from November 2019.

Figure 7

Comparison of Pre-PLC SASSY Designations to 2019 National Data

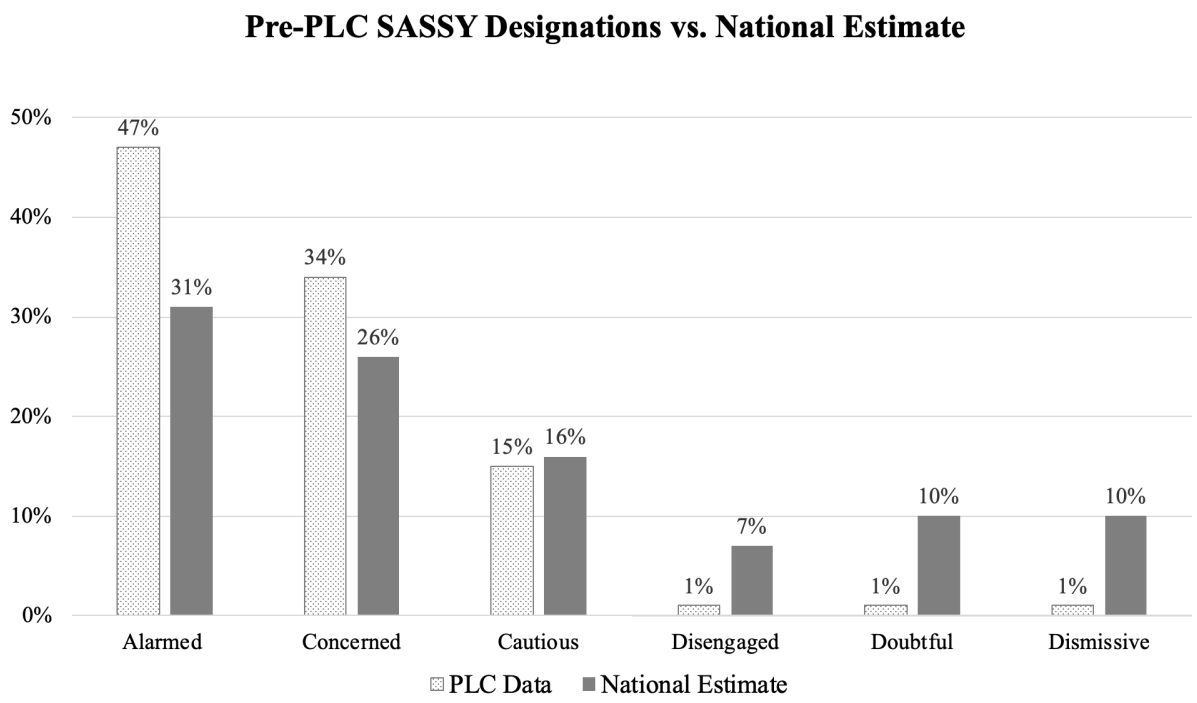
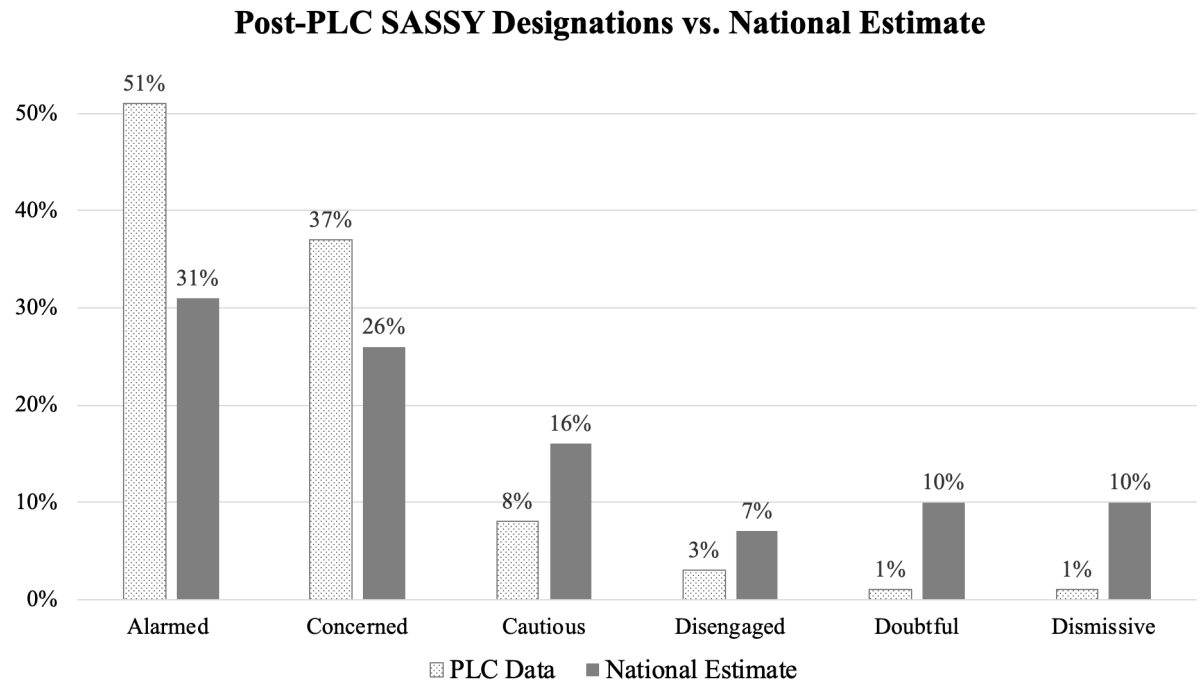


Figure 8

Comparison of Post-PLC SASSY Designations to 2019 National Data



Chapter 4: PLC Assessments Results and Discussion

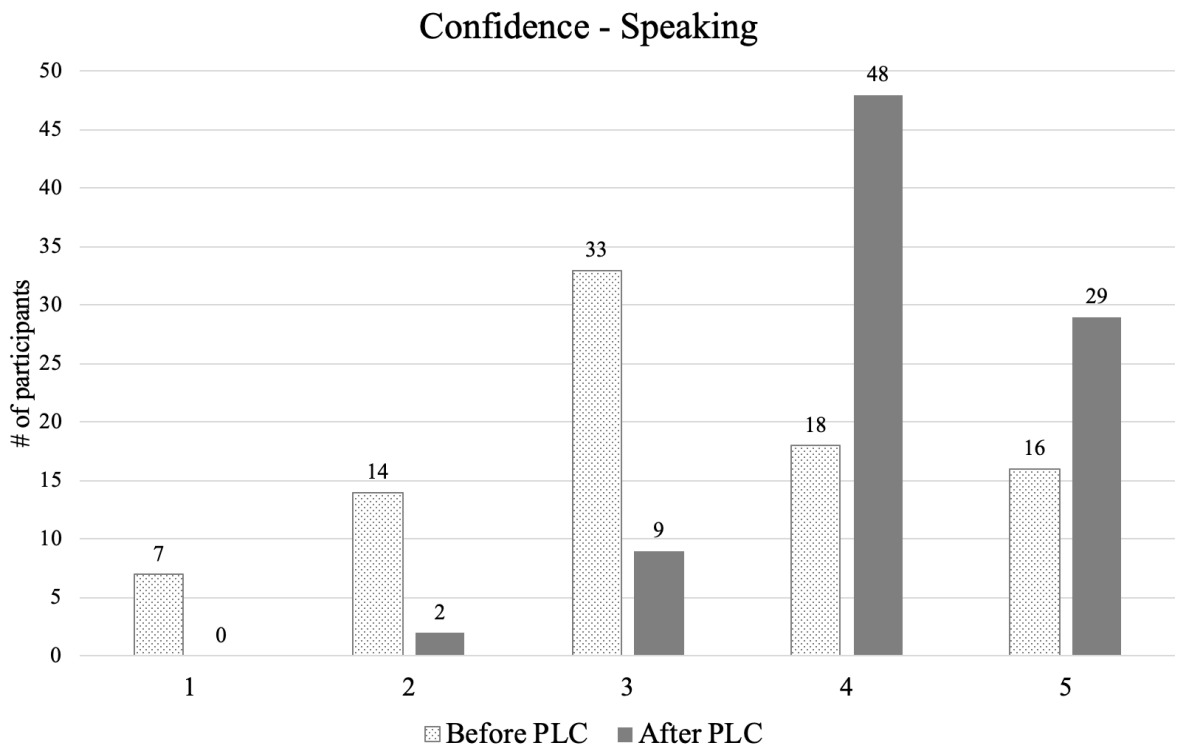
Confidence

In order to assess their confidence in speaking and writing about climate change, participants were asked to evaluate themselves on a scale of 1 to 5 in a post-then-pre survey. A post-then-pre survey allows students to self-assess their perceptions of changes in their behavior after participating in the PLC (Davis, 2003). A pre/post survey can be subject to response-shift bias, which occurs when participants experience a shift in understanding between the pre- and post-surveys, resulting in invalid data (Howard & Dailey, 1979). When students take a pre-test, they can overestimate their understanding of a topic. Upon realizing that they did not know as much as they thought they did, they may rank themselves lower in the post-test, even though they did learn from the event. Because a post-then-pre survey evaluates participants' pre- and post-PLC self-perceptions in the same moment, it is more likely that participants will evaluate themselves from the same perspective, thus eliminating any response-shift bias that could occur through the participants' experience at the PLC event (Howard & Dailey, 1979).

In order to understand how the activities at the PLC event caused changes in student confidence, students were asked to evaluate themselves on their ability to effectively speak with others, including those who hold different perspectives, about climate change before and after the event. Participants were asked to rate themselves on a scale of 1 (*not at all confident*) to 5 (*very confident*). The results of this assessment of student confidence in speaking about climate change are shown in Figure 9. Results are shown for 88 students who completed the post-then-pre assessment. A paired-samples t-test was conducted to compare student confidence in their ability to speak with others before and after the PLC. There was a significant difference in scores for before ($M = 3.2$, $SD = 1.2$) and after ($M = 4.2$, $SD = 0.7$); $t(1.99)$, $p < 0.00001$.

Figure 9

Confidence Speaking Before and After PLC



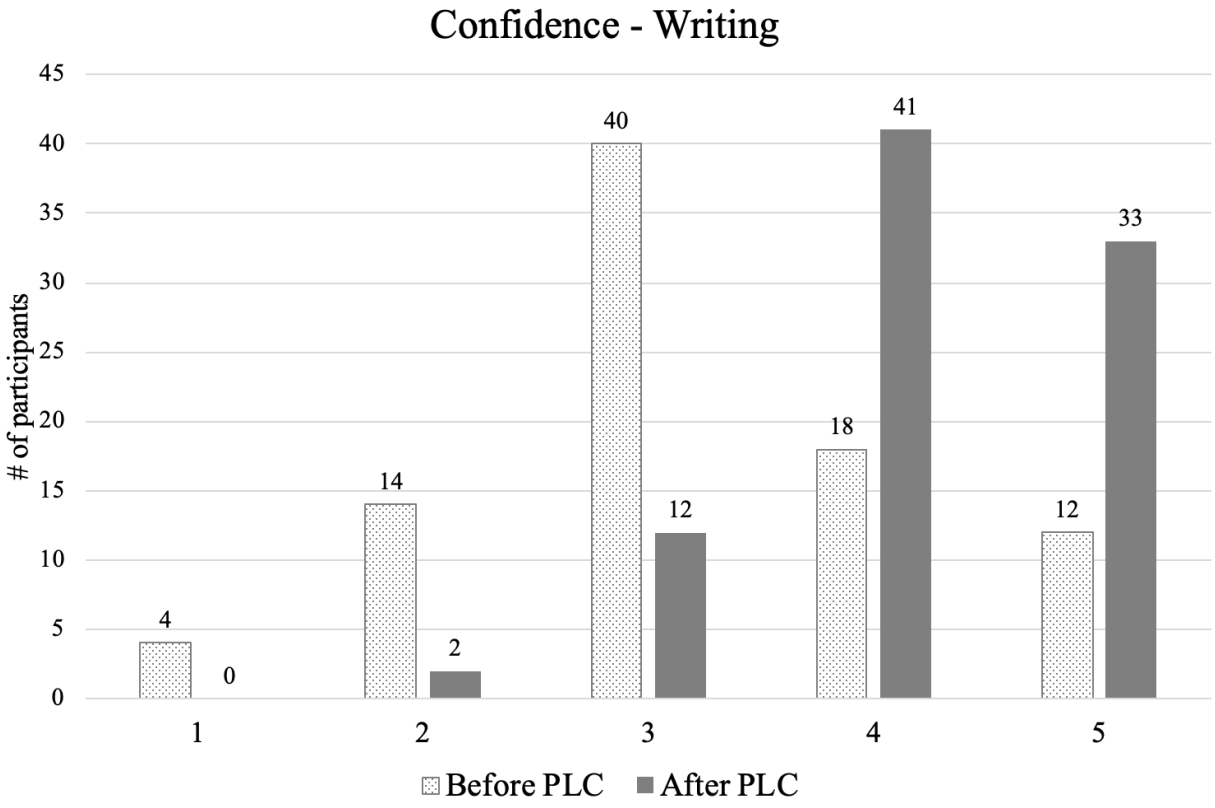
Note. Self-reported evaluation of students' confidence speaking with others about climate change before and after the PLC event's activities ($N = 88$).

Similarly, students were asked to evaluate themselves on their ability to effectively respond in writing to others, including those who hold different perspectives, about climate change before and after participating in the event's activities. Participants were again asked to rate themselves on a scale of 1 to 5. The results of this assessment of student confidence in writing about climate change are shown in Figure 10. This assessment was completed by 88 participants. A paired-samples t-test was conducted to compare student confidence in their ability to communicate in writing with others before and after the PLC. There was a significant

difference in scores for before (M = 3.2, SD = 1.0) and after (M = 4.2, SD = 0.7); t (1.99), $p <$ 0.00001.

Figure 10

Confidence Writing Before and After PLC



Note. Self-reported evaluation of students' confidence responding in writing to others about climate change before and after the PLC event's activities (N = 88).

After viewing the morning session confidence data, assessments were adjusted between sessions so that participants in the afternoon PLC session had the opportunity to express why they felt a change in confidence speaking and/or writing about climate change after participating in the PLC event. The table discussions, responding in writing to a social media post, and

watching the video of Greta Thunberg in Congress were parts of the event that participants mentioned helped them feel more confident. Participant comments from the post-PLC assessment are listed below.

- "My group members were very receptive to what I had to say and it made me feel confident in my feelings about how to go about climate change."
- "Seeing Greta [Thunberg] discuss and stand up made me feel more confident."
- "Talking to my peers about responding to the social media post was helpful. They pointed out some very interesting points that I did not think about much the first time I read it through."
- "Before this event, I was quite scared to express my opinion at all to anyone because I thought I would shut down for it. After this event however, I feel much more confident in expressing my opinions about not just this topic, but others too."

Understanding changes in confidence due to the PLC event was also addressed during the post-PLC individual interview discussed later in this document.

Matter of Opinion

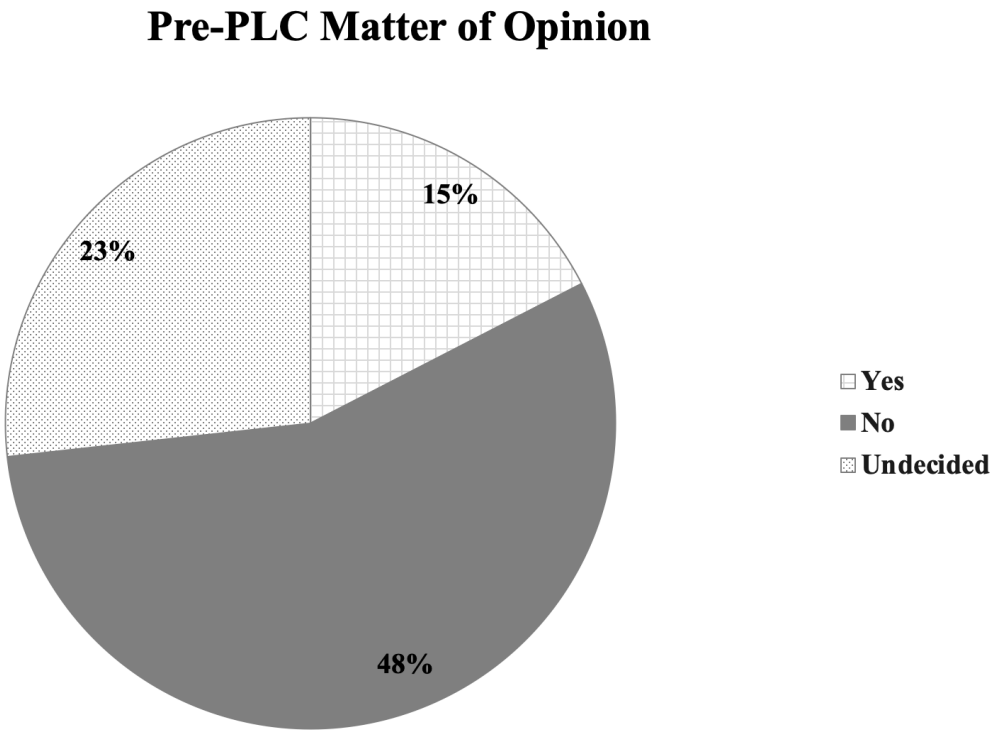
Prior to and after the PLC event, 86 students answered the following question:

- Do you think the need for action on climate change is a matter of personal opinion?

The response options were Yes, No, and Undecided. Figures 11 and 12 show how participant responses to this question changed after the PLC event's activities. More students believed that taking action on climate change is not a matter of opinion after participating in the PLC.

Figure 11

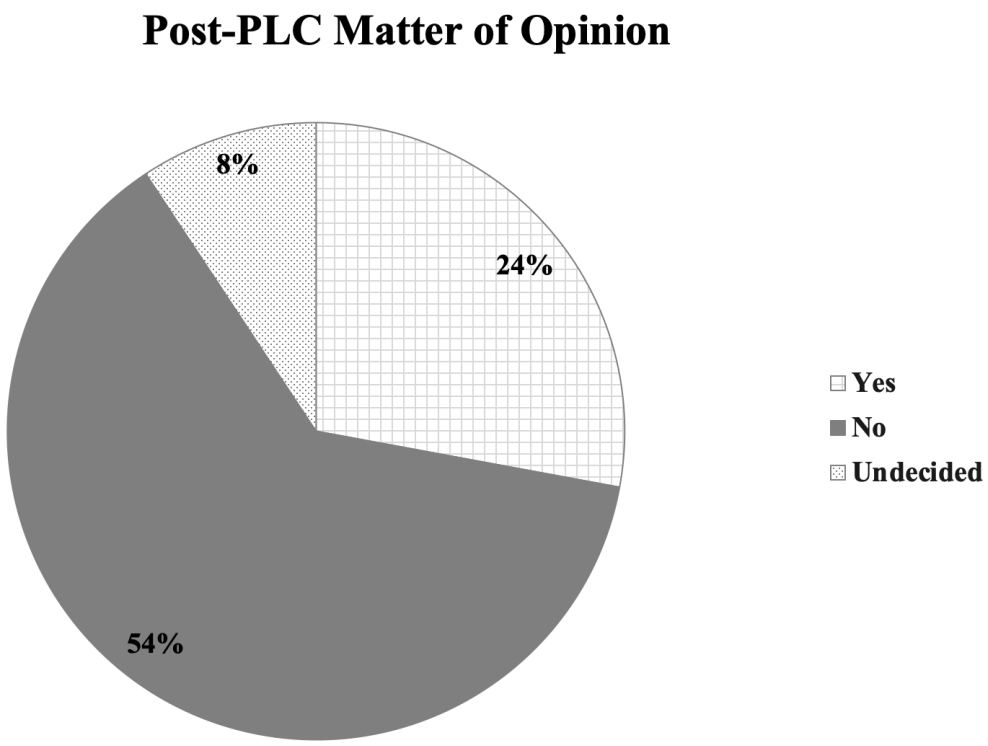
Matter of Opinion Before PLC



Note. Student responses prior to the PLC event regarding whether or not they think the need for action on climate change is a matter of personal opinion ($N = 86$).

Figure 12

Matter of Opinion After PLC



Note. Student responses after the PLC event regarding whether or not they think the need for action on climate change is a matter of personal opinion ($N = 86$).

In the post-PLC assessment when participants answered the matter of opinion question for the second time, students from the afternoon session had the opportunity to explain their responses. Between the morning and afternoon sessions, the event organizers decided to allow for explanations so we could better understand student responses to this question. Students who felt that "No, this was not a matter of opinion," felt that the evidence was overwhelming that climate change was occurring and that taking action was essential.

- "I think that the need of action on climate change is not a matter of personal opinion because there is so much evidence that supports it from educated,

qualified professionals that have studied this material."

- "Climate change is happening whether you 'believe in it' or not. The science behind it says that it is happening and it is going to continue to happen and worsen unless something is done so I don't believe that it is a matter of opinion, I think it's a matter of doing something or completely destroying the environment."
- "Climate change is happening regardless of one's ideology, religious, or social affiliation. Steps should and will be taken, but the severity of those steps will be less grievous and easier to implement if we can do this immediately and incrementally."
- "I think that there should be action done towards climate change and it shouldn't be a matter of personal opinion because everyone has their own opinion but if something is helping our planet, I feel like it should be done regardless of what people think because I feel that a lot of people are selfish."

Students who felt that "Yes, taking action on climate change was indeed a matter of opinion," felt that belief did not necessarily translate into taking action.

- "I think that people need to do a better job of taking care of our planet. People should recycle whenever they can and try not to be wasteful of resources, but the need to take huge, drastic actions on climate change is a matter of personal opinion. In general, people should want to take care of the Earth and try not to damage the atmosphere."
- "I think taking action on climate change is a matter of personal opinion because not everyone wants to make changes to their lifestyle for something that they might not believe in."

- "I think it is a matter of opinion, since we have to vote on it. It is treated as an opinion even though it should not be, since we only have one earth to live on and we should be protecting it regardless of if it is humans' fault or not."

The explanations for students who were "Undecided" seemed to hold beliefs that overlapped with students who responded "Yes" and "No."

- "I personally feel that climate change is an important issue, but everyone has their own morals and opinions and we cannot expect everyone to feel the same way."

This question yielded potentially unreliable data. Some students misunderstood the question and responded the opposite of what they intended and others were confused.

- "Yes": "Just because someone doesn't personally believe something DOES NOT mean it doesn't require action. Deciding the need for action should be a matter of tolerance regardless of personal opinion."
- "Yes": "The evidence that is available online through climate change experts has influenced me to believe that there should be a need for action on climate change."
- "No": "I thought it was a weirdly worded question. I believe climate change is real."

Additionally, the responses to this particular question may not be indicative of the participants' climate change beliefs and whether or not they think that climate change exists is a matter of opinion. Some students who answered "Yes" don't think believing that climate change exists is a matter of opinion, but they think taking drastic action is subjective, which could result in misleading data. Before the next iteration of the PLC event, this matter of opinion question will be revised and piloted in order to ensure that future participants are able to interpret the question

as intended.

PLC Reflections

The reflections that participants submitted after attending the PLC contained descriptions of the participants' experiences at the event and how these experiences influenced their beliefs, confidence, and how they use general education content and skills in new contexts. To analyze the PLC reflections, I developed a list of qualitative codes. These codes and their descriptions are given in Table 2.

Table 2

Description of Codes for Analysis of PLC Reflections

Code	Description
PLC Experience/ Takeaways	Response recalls overall experience at the PLC, including their general reaction to the PLC and what their main takeaways were
Climate Change Belief/Knowledge/Attitudes	Response discusses participant's climate change beliefs and attitudes and how their views were impacted by participation in the PLC
General Education Skills	Response discusses application of general education or disciplinary skills at the event and what skills they will use in the future
Table Discussions	Response relates to interdisciplinary table discussions during the PLC
Disciplinary Perspectives	Response discusses how different lenses can be applied to discussions of climate change and how each discipline can approach an argument from a different perspective
Confidence	Response discusses how PLC impacted their confidence speaking or writing about climate change beliefs
Personal Reflection	Response involves unique reflection based on the individual's personal background
Communications Exercise	Response relates to "Climate Change at the Dinner Table" improvisation activity during the PLC
Education/ Teaching Career	Response discusses how the event's activities or discussions on climate change will impact the participant's future career in teaching
Faculty Modeling	Response relates to faculty modeling segment of the PLC
Critique/Feedback on PLC	Response offers criticism or feedback on the PLC event, regarding its organization and content

Code	Description
Religious Beliefs	Response involves the relationship between climate change beliefs and the participant's religious beliefs
Writing Exercise	Response relates to the participant's written response to the social media post during the PLC

This set of codes describes all reflections that were submitted by participants. Each reflection contained at least one code, with most of the responses fitting the criteria for at least two codes. The frequency at which each code emerged in the dataset is given in Table 3.

Table 3

Qualitative Coding of Pop-Up Learning Community Reflections

Code	Total Frequency (*N* = 85)	Percent of Total Responses
PLC Experience/Takeaways	76	89.4%
Climate Change Belief/Knowledge/Attitudes	48	56.5%
General Education Skills	30	35.3%
Table Discussions	26	30.6%
Disciplinary Perspectives	16	18.8%
Confidence	15	17.6%
Personal Reflection	14	16.5%
Communications Exercise	11	12.9%
Education/Teaching Career	11	12.9%
Faculty Modeling	9	10.6%
Critique/Feedback on PLC	6	7.1%
Religious Beliefs	4	4.7%
Writing Exercise	2	2.4%

The codes for the PLC reflections can be placed into larger categories of responses. Throughout the PLC Reflections section of this chapter, there are subheadings to categorize the codes. I will first discuss how students were influenced by various PLC activities, including faculty modeling, interdisciplinary table discussions, the writing exercise, and the

communications exercise. Because we formally assessed student confidence, I compiled reflection quotes that discuss how student confidence was impacted through the PLC event. Students shared their experiences at the event by outlining their main takeaways and reflecting on their thoughts about the interdisciplinary nature of climate change discussions. Our discussion then shifts into reflections about how students applied, and will continue to apply, skills learned in their general education courses. The next section of the reflections data relates to feedback students gave on the PLC event. The analysis of student reflections closes with a discussion of how the PLC event impacted future educators and students who hold personal religious beliefs.

PLC Activities

The PLC activities had strong impacts on the participants. The faculty modeling allowed students to see how climate change arguments can be viewed through the lens of their disciplinary background and how climate change can be viewed from more than one perspective. Reflections on the faculty modeling portion of the PLC event comprised 10.6% of the participant submissions.

- "I thought that the teachers' models helped me to better understand how I was to respond to the topic at hand."
- "I learned how interdisciplinary climate change can be as all of the professor's present mentioned their role in climate change. The speech teacher greatly surprised me because I would never think about climate change as being related to speech."
- "It was helpful to hear from some of the philosophy faculty about common misconceptions and logical fallacies and how to recognize them in the hopes of responding to them without triggering people's defensiveness."

- "It was interesting to see the professors come together from multiple other courses and see the presentation that they have gathered. It was nice to learn some of the models and how to approach different information from different perspectives. Being able to back up information from multiple different perspectives only strengthens your ability to efficiently communicate."

Students were able to practice responding to a climate change argument from a mock social media post through writing, both before and after interdisciplinary table discussions. The table discussions helped students both learn about new perspectives and grow more confident in their own beliefs. The PLC provided a supportive environment for students to discuss a controversial topic and the table discussions helped promote better understanding of climate change in general and how to have productive conversations about how to combat it. The writing exercise and table discussions were brought up in 2.4% and 30.6% of the reflections, respectively.

- "First, I liked being able to respond to the written text just with my own prior knowledge just to see what I thought I knew. I thought it was then very beneficial to be able to discuss as a group and revise my own response."
- "The people at my table and everyone I talked to had pretty much the same thoughts as I did about climate change. But it was good to talk together as a group and discuss theoretical situations that you could be in and how you could respond in a positive way."
- "My fellow participants were really helpful in helping me understand the effects of global warming."
- "I think hearing others talk allowed me to become more knowledgeable about climate change and allowed me to solidify some of my opinions about it."

Just as the writing exercise allowed students to practice responding to a climate change argument through writing, the "Climate Change at the Dinner Table" activity provided participants with an opportunity to respond to arguments orally. The communications exercise allowed participants to practice using their disciplinary perspectives and general education skills. The exercise also opened some students' eyes to how language and communication connect to climate change arguments. The improvisation exercise was brought up in 12.9% of the participant reflections.

- "The improv activity forced me to voice my opinion to a stranger. This activity made me more comfortable with public speaking, and how to come to a common ground with a stranger. Personally I need activities like this, otherwise I will stay silent and keep thoughts to myself."
- "I liked the part of the seminar when we interacted with others about the questions that were presented. It gave me an opportunity to communicate with others calmly and effectively."
- "With the practicing of discussing with friends we did, it gave me a better insight on how to see where people get their information and further formulate a discussion with that person."
- "I think by staying calm, collected and patient I can reach those who may have a different perspective than myself and they may be more willing to listen."

Confidence

While we did not collect explanations from students who attended the morning PLC session regarding shifts in confidence speaking or writing about climate change, 14 PLC participants wrote about changes in their confidence or comfort levels with climate change discussions in their reflections. Students shared about increases in their confidence discussing

climate change through conversation or writing, how their experience at the event was empowering, and how the confidence built through activities during the PLC will carry through in their personal and professional lives. The event also drove some students to take action, whether by raising awareness on the issue or by trying to lessen their personal contributions to climate change.

- "I also learned that my opinion is just as important as everyone else's and that there are many different ways to look at a topic or issue."
- "In my personal life I will be more confident with my opinions, and treat what I bring to the table as important. I will also try to stop backing down from disagreements and find the common ground, and review both aspects and how it can build my knowledge. For my professional life especially with a boss, I will again be more confident and firm when I communicate."
- "I do not think I will be as nervous to talk about what I believe. I also think that I will read more so that my confidence will continue to grow."
- "Going to this event made me feel confident, because I was educating some of the people in the room on what was happening."

PLC Takeaways and Reflection Prompted by Event

Through the reflections, 89.4% of students shared their main takeaways from the event and the most important parts of the PLC experience from their point of view. Some participants learned the importance of distinguishing weather from climate.

- "One of the main important things I learned at the event was how to differentiate climate from weather."
- "I think the most important part of explaining climate change is informing the

listener about the difference between weather and climate. A person should you use facts when communicating about climate change. You could use emotions to steer someone to the fact that climate change is going to impact future generations immensely, but it should not be used to discredit or disprove a person."

Some students shared their concern that peers, politicians and government leaders are not taking environmental issues seriously.

- "I learned that there are many people who do not care as much about climate change as I do. That may sound weird but I had assumed that everyone in my generation cared as much about these issues as I do."
- "I learned that there are a lot of people who deny climate change and a lot of them are in positions of power. Change will not happen until the important people of this world can agree that it is happening."
- "The biggest take away I had was the blatant ignorance that high level officials of our government have regarding climate change. I feel personally they do not care as much as they should, simply because it will never impact them personally during their time on this Earth."

For some, the PLC event prompted them to take action or learn more about climate change.

- "My attitude going into this was that climate change is important, but not important enough to start action now. I firmly believe now that we should take little steps everyday to help our environment."
- "I really enjoyed the presentations and the activities we did. The information provided was very attention grabbing and it made me want to take action and change how I live to decrease global warming."

- "From my personal view I feel it's very important to spread awareness so people can take care of the environment and come up with solutions for environmental pollution."
- "I learned that there is never one answer to problems in our society."

Participants also discussed the importance of information literacy and interpreting scientific information correctly.

- "When it comes to applying what we learned, I think what's really important is that we read up on actual, scientific facts in order to not spread misinformation and be able to recognize and combat faulty or just generally poor arguments."
- "We need to find ways to save our planet and we need to educate the public on what data is and how to interpret scientific information."

Application of General Education Skills

One of the main goals of the PLC event was to understand how students in general education courses apply skills and knowledge to a new context. Discussions of how students used general education skills during the PLC, and how participants will continue to use these skills in the future, was contained in 35.3% of the PLC reflections. Students learned how to be more effective listeners and communicators.

- "Today in the pop-up learning community I learned how we can use our knowledge that we learn in gen ed's in our everyday life."
- "I have the skills to figure out if what someone is saying is true, and if it actually presents a valid argument or if it is just trying to put down the opposition. I will use all the skills that I have acquired while taking gen ed's here at EMU to dissect future information that is presented to me."

- "My general education courses are teaching me different subjects and by doing so, I am ultimately building what I would call my 'tool box.' I need to use my 'tool box' when looking at different problems and dilemmas regardless if they are part of my personal life or in my professional life."
- "Listening to people and keeping an open mind can help you understand different perspectives."

PLC Feedback

As with the interviews, the reflections provided participants with an outlet to provide feedback on the PLC event. Six students shared how they would alter the PLC event for the next iteration due to their individual experiences.

- "I didn't know that there was going to be assigned tables, which forced me and my peers to have a controversial conversation with essentially strangers."
- "I would say that I would have liked to really define and objectively talk about more climate change points as it felt like to me the students there from philosophy or physics did not have the background to really talk about the subject as objectively as they wanted to."
- "Participating in the Pop-Up Learning Community was beneficial to my confidence about talking about the topic, but I wish it would have been more informative on the topic global warming."
- "I wish we had more time to really dive into the discussions, because a couple of group members who were more extroverted led the conversations and I noticed there were 2-3 people who didn't say much of anything unless directly asked."

Education

In the reflections, 11 students talked about their future teaching careers and how they would incorporate what they learned or observed at the PLC event into their own curricula. Many students wrote about how they hope to encourage a sustainable classroom climate and talk about solutions to climate change.

- "As a teacher, I plan to encourage my students to take care of the earth!"
- "I do look forward to being a teacher when I can inform my students and hopefully encourage them to make earth friendly choices, or perhaps even bring new solutions to the table."
- "I am an elementary education major, so I think there is a lot I can do as a future teacher to make a difference and communicate the need for change. As a teacher, if I can get my young students to realize what an issue this is, they will carry it through their entire lives to change things. Our children are the future of this world and think they will see the harm that is being done to the environment more than anyone else. They will see these problems and see that they need to be fixed."

Pre-service teachers also reflected on strategies they hope to bring into their classrooms in regard to skills they hope to strengthen as educators as well as skills they hope for their students to develop.

- "I hope that as an educator, I will find a way to meaningfully communicate what I need to say [about controversial topics] fully and clearly."
- "I do think it's important to talk about the subject in a science classroom and the PLC has started to prompt my thinking about how to do this effectively. I have

probably spent more time thinking about how to discuss evolution and natural selection with students as a biology-focused teacher, but climate change is arguably a more important battle to fight pragmatically due to its impact on us and future generations."

- "I think professionally I also learned more about what people believe so if I chose to do a lesson about climate change and the impacts it has I can do it in a way that is educational and informative without offending others opinions and allows them to see the scientific facts and data as a whole."

Some reflections proposed lessons they could design to teach about climate change and why bringing climate change topics into the classroom is important to them.

- "As a future educator, I plan on implementing the discussion of climate change throughout my lessons. For example, if I am talking about a scientific phenomenon, I can relate it to current issues and on the topic of climate change. Like on the topic of greenhouse gases, I can discuss with my students and have them realize that from a small model, like a greenhouse, we can see how the greenhouse warms up. I then would be able to relate this to the world overall!"
- "I know for a fact that I will be including climate change into my lesson plans when I become a teacher, because I want the future generations to know what has happened in the past, in the present, and in their future. They deserve to know what is happening because they are also the ones who will be combating climate change with my generation and the subsequent generations after that."

Religious Beliefs & Climate Change

Four students included reflections about their religious beliefs and how that informs their views on climate change. One of these participants addressed the challenge of reconciling science and religion.

- "I personally believe based on my Christian faith not that God will just 'come fix all our problems,' but that we might not even be on earth long enough for it to matter. Again, I still think we should do our part in protecting the environment because God created humans to take care of it!"
- "I believe as both a Christian and a scientist that it is my personal responsibility as well as the personal responsibility of every human to do my part in taking care of the environment I live in and share with others."
- "I have always had a difficult time with my Catholic religion while taking science classes and this particular discussion hit home for me. My religion/philosophy does not have to overrule or be overruled by my beliefs in science. Rather, the beliefs are interconnected even if I cannot find the connection quite yet. Still, science and religion are separate entities (I know this thanks to having learned about the nature of science!)"

Chapter 5: Individual Interviews Results and Discussion

I conducted individual interviews with pre-service elementary and secondary teachers from CHEM 406/407. The purpose of the interviews was to learn more about how students define climate change and its impacts and how they plan to incorporate climate change topics into their lessons, if at all. The pre-PLC interviews focused on students' climate change beliefs and how prepared they feel to teach about climate change. The post-PLC interviews were done to see if the PLC event caused any changes in the participants' climate change beliefs or their confidence speaking or writing about climate change. In the post-PLC interviews, students were also given the opportunity to provide feedback or suggestions about their experiences at the PLC to the organizers of the event.

Each participant was assigned a gender-neutral pseudonym to maintain confidentiality. The pseudonyms are included with each participant quote in this chapter so that the reader is better able to differentiate between participants for both the pre- and post-PLC interviews. Table 4 lists all pseudonyms to show the distribution between the elementary and secondary pre-service teachers that participated in this study.

Table 4

Pseudonyms of Individual Interview Participants

Pre-Service Teacher Age Group	Pseudonym
Elementary	Avery, Charlie, Jordan, Morgan, Peyton, Sam
Secondary	Bailey, Blake, Joey, Riley, Rory, Shawn, Taylor

Pre-PLC Interviews

To analyze the pre-PLC individual interviews, I developed a list of qualitative codes. These codes and their descriptions are given in Table 5. Examples of student quotes that align with these codes are given throughout this chapter.

Table 5

Descriptions of Qualitative Codes for Analysis of Pre-PLC Interviews

Code	Description
Confidence/Comfort Level	Response discusses how confident, comfortable, or prepared the participant feels teaching or discussing climate change topics
Climate Change Perceptions	Response includes participant's definition of climate change and what they view as the causes and consequences of climate change
Formal Education	Response discusses formal climate change education that the participant received during K-12 or higher education
Informal Education	Response discusses sources of informal climate change education, including reading academic or social media articles, discussing with friends or family, or watching environmental documentaries
Lesson Design	Response offers ideas for designing climate change lessons and discusses ways to do more research or incorporate experiences from college courses into lessons for their students
Teaching Challenges	Response discusses what challenges the participant foresees in teaching climate topics in their own classroom
Concern	Response relates to the participant's personal concern in regard to the impacts of climate change on themselves or future generations

Code	Description
Solutions to Climate Change	Response offers potential solutions to climate change, both in regard to climate change education and environmental protection
Politics	Response discusses the relationship between political views and climate change belief, as well as how climate change is being handled by United States policymakers
Personal Anecdotes	Participant recalls how personal experiences have informed their climate change beliefs
Hopes for PLC	Participant references how reflecting on their climate change beliefs and views will impact their experience at the PLC, as well as what they hope to take away from the PLC

Each interview contained multiple codes based on the participants' responses to my prepared interview questions. The frequency at which each code emerged in the dataset is given in Table 6.

Table 6

Qualitative Coding of Pre-PLC Individual Interviews

Codes	Total Frequency (*N* = 13)	Percent of Total Responses
Confidence/Comfort Level	13	100%
Climate Change Perceptions	13	100%
Formal Education	13	100%
Informal Education	13	100%
Lesson Design	13	100%
Teaching Challenges	13	100%
Concern	8	61.5%
Solutions to Climate Change	7	53.8%
Politics	5	38.5%
Personal Anecdotes	4	30.8%
Hopes for PLC	3	23.1%

As with the PLC reflections, the codes for individual interviews can be separated into various categories. For the pre-PLC individual interviews, the subheadings follow the general outline of the interviews themselves. I will first address how comfortable the participants felt discussing climate change topics, which will then transition into the participants' own climate change beliefs. These beliefs were influenced by formal and informal climate change education and students were asked to share what sources influenced their views. The discussion then shifts to how participants feel in regard to teaching about climate change. This section involves how

prepared these pre-service teachers feel to teach about climate change, as well as what challenges they foresee and how they plan to design lessons. The analysis of pre-PLC interviews concludes with closing thoughts from the participants.

Comfort Discussing Climate Change

All 13 participants told me that they felt comfortable talking about climate change, but they were uncomfortable with the amount of knowledge that they currently possess. Some students expressed concern with their lack of comfort with climate change facts that would inhibit their ability to educate others.

- "I'm comfortable talking about the subject. I just need to be educated more on it to be able to fully be comfortable to have a professional discussion." (Peyton)
- "I feel mildly comfortable. The things that I just worry about are the specifics. Trying to scientifically explain all of it is a little confusing." (Jordan)
- "I feel like I can provide some framework on it. It would definitely take a Google search before giving someone reasonable data." (Joey)
- "I feel very comfortable speaking about it but not perhaps as well-educated about it. I want to tell everybody about it but once it gets a little more detailed I'm not the expert to go to." (Riley)

For Bailey, a secondary education major, concern was a motivator for becoming more confident in their abilities to discuss climate change.

- "I feel like it's something we should be aware of so I try to keep informed about it." (Bailey)

Blake, also a secondary education major, noted the controversy that can be associated with climate change and other environmental topics.

- "It's almost akin to talking about politics in the classroom." (Blake)

Climate Change Background and Beliefs

All 13 participants shared how their formal and informal climate change education has informed their climate change perceptions and beliefs. Both elementary and secondary pre-service teachers felt that their formal climate change education was limited. In general, the greatest contribution to formal education on climate change was through the students' majors in a science field.

- "I have the science background but not necessarily the climate change background." (Bailey)
- "I think most of my education in climate change is formal, just from being a science major." (Charlie)

Two of the primary education students mentioned an earth science course focused on weather and climate that added to their climate change knowledge. Students also mention other courses and academic experiences that have increased their knowledge about climate change.

- "My weather class talked a lot about climate change and the mechanics behind the science of it and then, since I'm a science major in the program of course I have [chemistry courses for elementary teachers] where we've talked about climate change." (Jordan)
- "I'm in a weather and climate class right now so we're kind of touching on it but we haven't really done that deep yet. I did go to the [2017] Pop-Up Learning Community. I remember learning a lot from that." (Peyton)

Similarly, secondary education pre-service teachers pointed to an ecology course as making up most of their background in climate change education. All students that brought up this particular

course remembered a lesson about the impact of climate change on ecosystems.

- "I'm a biology major so it comes up a little bit in the context of ecological studies and the changing climate and how that impacts ecosystems, but formal education is pretty limited about that." (Riley)
- "[None] besides what I've discussed in ecology classes, like the effects [of climate change] on ecosystems." (Rory)
- "I know I've had a couple professors try to talk to us about climate change and I'm always for it. [In] my ecology class I took two years ago, [the professor] was always trying to incorporate some kind of climate change aspect within every lesson or material that we're covering. [I'm] trying to think of a specific example that she did with forest fires and whatnot and how that changes the ecosystem of everyone living there and the animals and the plants." (Shawn)

A couple of participants did not remember climate change being specifically taught or discussed in any of their college courses.

- "I don't think we've ever addressed it in any of the classes that I've ever been in." (Avery)
- "As in education, nothing formally. No courses on climate change or even specific lessons on climate change really." (Sam)

As far as informal education, the most common responses related to having discussions with family members or peers, doing independent research on climate change, or seeing stories or articles on social media.

- "Reading articles. If I can't find something, I go research and see if there's anything else I can learn about [climate change]." (Bailey)

- "I just research on my own or discuss with people that it is happening." (Peyton)
- "Most of what I get would be from social media sites that tag different papers, which might come from legitimate peer-reviewed journals to begin with but then they go through filters and then get thrown out by politicians or sites like Move On." (Riley)
- "Informally, just listening to podcasts. NPR does a lot of stuff on climate change." (Sam)
- "Online [on] social media, I talk about the importance of climate change, but I don't do anything direct, like going out to protests or marches, which I kind of feel guilty about but I try to raise the attention through all other means." (Shawn)

To get a better sense of how science-focused pre-service teachers define climate change, I asked them what the term "climate change" means to them personally. Most responses were rooted in scientific evidence or explanations of environmental phenomena. Blake, a secondary pre-service teacher, and Jordan, an elementary pre-service teacher, related climate change to pollution.

- "At this point we are introducing a lot of CFCs and that climate change is a result of an atypical rate of introduction of these materials into the atmosphere." (Blake)
- "It means that our world is dying. More particularly I guess it just means that there's so much pollution that our world is warming and crazy things are happening [in terms of] extreme weather." (Jordan)

Many participants noted the general interpretation of climate change, being that the climate is changing. Some had a definition of climate change that related more closely to global warming, exemplified by Riley, a secondary education major's, response.

- "Climate change for me is a trending warming of our planet." (Riley)

A common misunderstanding with climate change occurs when weather is mistaken for or equated to climate. Charlie, a primary education major, discussed the importance of differentiating the two terms.

- "The biggest thing for me is that it's different than weather and that's one of the most important things to understand about climate and weather is that climate's over a big span of time. It's a large set of data that scientists study whereas weather is more of a day to day kind of thing and I think people who aren't heavily immersed in science confuse the two." (Charlie)

Rory, a secondary education major, discussed the difference between natural changes in global climate and human-caused climate change. Shawn, a secondary pre-service teacher, agreed with this departure from natural processes that our planet undergoes.

- "On one level climate change is something that happens. There have been major climate changes in certain points that are a sustained pattern, so there's ice ages and stuff like that and that's been something that has happened multiple times in the past, so it is a natural thing. But there's also human-caused climate change, what's currently happening right now." (Rory)
- "Climate change means the Earth is getting changed in a drastic way that's unnatural. It's not going through its natural process of how it should be as the Earth." (Shawn)

In a similar vein, Bailey, a secondary education major, talked about the relationship between human action and the Earth's climatic response.

- "To me it's the condition we keep [our planet] in affects how our planet responds in terms of climate increases or decreases. The way we are treating our planet is

how our planet responds back to us." (Bailey)

For Sam, an elementary pre-service teacher, this current human behavior may lead to an uninhabitable planet.

- "To me it just means that the climate is changing and right now it's going in a direction that's probably not suitable for life if it keeps going in that direction." (Sam)

Joey, a secondary education major, spoke on how climate change, as a term, is received by the general public. Joey shared his concern about how taking action on climate change continues to be deferred to the next generation.

- "I think [climate change] is an ever-evolving word. It changes with the more knowledge that we learn about it. With that it keeps evolving and eventually climate change is going to become a real panic word, as more and more [of the responsibility] keeps getting placed on the younger generations. Right now I think it's just a buzzword that I think most people don't recognize yet." (Joey)

The majority of participants mentioned their science courses or other formal education when thinking about what experiences have influenced their definitions of climate change. However, some also said they want to have more climate change education that could inform their understanding or beliefs about climate change.

- "Going to school currently for science and wanting to be a science teacher." (Charlie)
- "If I had more of a formal understanding and learning of it I would have a deeper meaning and understanding." (Peyton)

The fact that climate change has become a central issue for many politicians and activists also

influenced students' climate change beliefs. As the public becomes increasingly aware of environmental issues, pre-service teachers as citizens have become more interested in taking action themselves.

- "Seeing more and more [political] candidates raise issues on awareness of that is making it seem more and more like it's an important thing because, growing up, I didn't really think much about climate change. So seeing those people talk about it and seeing that it's such a big thing, it's starting to affect me. It just raises an urgency to me to think about and act to help fight the cause." (Shawn)

Furthermore, witnessing the imminent nature of climate change and related environmental issues have caused pre-service teachers to reflect on the importance of bringing these topics into their own classrooms.

- "I've been able to grow up in a time period where it's become a big issue. We're the generation that gets to witness everything happening so it really lets us see the extremes of it." (Bailey)
- "The importance of being a future educator and knowing that the people that I teach will have to deal with these problems more directly than we are right now. It's affecting us now but you can choose to ignore it right now. In the future they're not going to be able to choose to ignore issues like climate change and so I feel a really strong responsibility to prepare kids for that." (Jordan)

Both formal and informal education has influenced these pre-service teachers' understanding of climate change. For those who use social media as a source for their climate change knowledge, doing more research and checking for the reliability of the data in the articles was essential.

- "You have to filter articles that you see on Facebook and make sure that they're

reliable articles and information." (Charlie)

- "Social media does play a big part of it. Usually I have to do my own digging before I come to an understanding of 'that is true what I just read on Twitter,' for example. If someone shows you a social media tweet, is what they're showing real or is that stretching the truth?" (Joey)
- "Lots of what's on Facebook you can't really believe. People don't really research the stuff that they look at before they repost and don't really check the scientific backing of anything." (Jordan)

Besides articles shared on social media, some education majors hear about climate change from news media or academic journals.

- "It's mostly the news and reacting to the news." (Rory)
- "I don't tend to use social media because people don't always read the articles that they post, so I tend to stick to find[ing] scientific articles." (Bailey)

Many students listed coursework or influence from faculty members as greatly informing their climate change beliefs.

- "Participation in the integrated science program would probably be the biggest thing." (Blake)
- "...discussions with biology faculty that I consider experts and respect." (Riley)

Shawn, a secondary pre-service teacher, wondered if students from other departments would share the same level of concern for climate change.

- "I'm taking all these science classes so I'm not sure if I were in a business class where they might want to talk about building factories [that] they don't care about climate change as much." (Shawn)

One elementary education student, Sam, talked about how he seeks out information sources that support his views on climate change.

- "I guess I'm more one-sided on [climate change]. I dig through things that I know will feed my way of thinking." (Sam)

After getting a sense of the participants' definitions of climate change, we discussed the potential global and personal impacts that climate change may cause in the future. When thinking about how climate change impacts our planet, some students referenced effects that we currently see around the globe.

- "Humans are emitting a lot more greenhouse gases than the Earth is used to having naturally. It's heating our Earth up faster than it naturally should." (Charlie)
- "There are island nations drowning because of water levels rising because ice caps are melting every day." (Joey)
- "We are harming our ocean, which is a big source of CO_2 intake for us. We are destroying the Amazon rainforest, which is also another source of oxygen and CO_2 intake." (Bailey)

Rory, a secondary pre-service teacher, made the point that educators shouldn't make blanket statements about the effects of climate change.

- "It's hard to make huge general statements other than the global temperature on average is rising, because [climate change] might not necessarily mean the same thing in every climate depending on the region, the normal climate, and the ecosystem that is present there." (Rory)

Participants also talked about the impacts that rising sea levels and temperatures might have

regarding our food sources and habitats.

- "Everything that is going to directly affect us is stuff that doesn't affect us that much [now], like glaciers melting and sea levels rising. Soon enough we might not have bees to pollinate our fruits and vegetables and people who live on the coast can't live there anymore." (Jordan)
- "We're going to have to find new places to grow our food." (Blake)
- "It's [going to] get rid of habitats for not even just us humans but animals." (Shawn)
- "I think the rate at which we're accelerating [climate change] and our inability to adjust will have some extreme consequences as the things living with us will not be able to keep up with the rate of change." (Riley)

Responses regarding personal impacts of climate change were more varied. For many of the participants, they did not feel that climate change impacted them at all personally, but did think it would affect future generations, particularly their own children.

- "I'm concerned about the welfare of future generations." (Rory)
- "[Climate change] may not affect me but it'll affect my offspring." (Morgan)
- "It makes me very insecure as a young parent about what's going forward." (Riley)
- "It has me second guessing if I even want to have kids in the future because this is not where I would want to raise someone to live in." (Shawn)

Others said climate change impacts them personally because they have changed their behavior to lessen their personal contributions to pollution and other environmental issues.

- "Personally I try to do things that are better for our environment, like I try not to

make a ton of trash. There's decisions that you can make that limit what you're putting out from what you're bringing back in." (Bailey)

- "I take time to recycle. I have a reusable water bottle, 'cause at the end of the day it is my planet and I will see the aftereffects of what I've done." (Joey)
- "I've been vegan for [about] three months now so I'm trying to reduce my carbon footprint that way. My sister [and I] carpool so that she doesn't have to drive here, too." (Jordan)

Pre-service teachers felt that climate change will affect how they teach their students, especially in regard to lessons and classroom climate.

- "It affects me teaching-wise because you have to figure out actually what it is and how to explain it, so just being able to relay it to my classroom." (Peyton)
- "It affects me especially as a future teacher. I want to set a good example for kids and I want to make sure that I'm recycling and I'm doing the things I can do so it doesn't have to affect us as much in the future." (Jordan)

Joey, a secondary pre-service teacher, shared about his job as a delivery driver and the dilemma he faces about his personal contributions to climate change.

- "I unfortunately don't have an electric car so I feel bad that I personally profit but that each time I have to fill up the gas tank knowing I'm ruining my air quality. Eventually I have to find a point to say, 'is this fair for everyone else or do I need to find a different job?'" (Joey)

Some responses from the pre-service teachers indicated that they weren't sure how climate change affected them personally.

- "I don't think it really does affect me at all." (Blake)

- "It's fairly indirect at this point. So it's not like there are no effects, I just don't always know what they are." (Rory)

Riley, a secondary education major, felt that the political treatment of climate change had the greatest personal impact.

- "Our current political administration makes me embarrassed and frustrated that they are expressing very little interest or trust in the scientific community to see if [climate change] is something that should be validated and taken seriously." (Riley)

As with their definitions of climate change, the sources that have influenced pre-service teachers' thoughts on the personal and global impacts of climate change are formal science education, social media or online articles, and current legislation that is covered by news media outlets.

- "I think the science background that I have and the knowledge that I have gained from education has made an impact on it." (Avery)
- "Being here at Eastern as a science major and taking courses." (Charlie)

Constant access to smartphones and the internet has impacted the amount of information the participants are able to consume. Students mentioned social media sites as well as news podcasts as ways they learn more about the impacts of climate change. The same students that pointed to social media as a primary source for their climate change knowledge also indicated that they felt negatively that this was the case.

- "Most of my information comes through social media, so the big one being Facebook as horrible as that is." (Riley)
- "Majorly, it probably is social media 'cause that's the thing I'm on the most, so seeing what people are posting and saying and reading their thoughts. Unless it's

a really trending topic then that's really what gets my attention, which stinks [laughs]." (Shawn)

- "[In regard to global impacts] that would just be from Science Fridays NPR for sure." (Sam)
- "Everyone's at least looking at [their phones] hours a day. At the end of the day I'm probably going to see stuff online or on my phone more than I will in a classroom." (Joey)

Riley, a student whose interviews contained political themes, referenced current legislation about climate change and how information and data can be manipulated depending on the source.

- "The Green New Deal that's coming out now gets a lot of coverage and a lot of their sources come from the scientific community that are then kind of mashed up and distributed through the political filter." (Riley)

Climate Change Teaching Preparation & Expectations

At this point, the interviews transitioned toward a focus on teaching preparation and lesson design. I first asked the pre-service teachers how prepared they felt to teach lessons or activities about climate change. One secondary education major, Blake, felt prepared to teach due to strategies learned through teaching courses at Eastern.

- "Pretty prepared. [The teacher preparation program has] done a fairly good job with encapsulating teaching strategies and showing us specifics that are demonstrable within the classroom." (Blake)

Multiple participants noted that they would feel more prepared if they were able to do more research on climate change, but they would not feel comfortable talking organically about climate change with their students. Other students felt that they did not feel adequately prepared

to teach climate change lessons.

- "I think if I did more research I'd be better prepared." (Avery)
- "I'd say if I was given the opportunity to have a week to make a lesson plan I could do it. If I was told to walk into a classroom and just start talking about it, I don't know how far I could get at all." (Joey)
- "Not super prepared. If you put me into a room today, I would need sources and materials to go through first. I wouldn't feel confident just coming up with something on my own." (Sam)

For some, the conversation shifted to the importance of making climate change content relatable for their students.

- "You want to tie in lessons to things that are relevant to children because if not they don't really care, especially if they're young. It's something that if you talked about it enough in a way that seems interesting enough they may go look up something themselves and come to some conclusions by themselves that you can help guide them further with." (Bailey)

Charlie, an elementary pre-service teacher, felt moderately prepared to teach about climate change but emphasized the importance of feeling comfortable with the material before extending a lesson to your students.

- "As with any lesson with science - or with any lesson as a teacher - I definitely think it's important even if you are strongly knowledgeable to always review what you're doing before you teach it just because you don't want to relay incorrect information." (Charlie)

To get a better sense of what has informed students' comfort level to teach about climate change,

I asked them to share some experiences that have helped them feel more prepared. The pre-service teachers mentioned past teaching experiences or skills they have learned in their teaching courses that they can use in their future classrooms.

- "I'd say student teaching here is a pretty good experience for that because you're thrust into a classroom and given three months to work with kids and in that time frame there are moments when you're the only person in the room and we are required to teach an individual lesson when we're teaching so I think that part gives you the confidence and then my [science] background gives me the data confidence part of it."(Bailey)
- "Honestly kids these days are concerned about this so this is something that they will actively seek out and want to learn about rather than you trying to enforce some sort of scientific model onto them. Interest always makes things easier to teach." (Blake)
- "It's a learnt skill to frame a discussion so you're not telling the students what to believe but you're enabling them to think critically about it and think about where they're getting their information from." (Rory)

In addition to formal preparation, Jordan, an elementary education major, talked about how enthusiasm for environmental topics can translate into your teaching.

- "I feel like passion is a huge part of it. If you are passionate about saving our planet then it will reflect in what you teach." (Jordan)

I also asked the participants what they think could be done in the teaching program to help them feel more prepared to teach about climate change topics. Several students mentioned integrating climate change lessons into existing courses or creating courses focused on climate change or

environmental topics in general.

- "I think maybe having a class about it 'cause I don't think I've ever had a class on it or a section on it." (Avery)
- "Unfortunately we only have a one credit hour class currently that I'm in." (Joey)
- "I think the one lesson we did in chemistry is pretty much all [elementary teachers] have really had." (Morgan)
- "I guess just more in depth looks at climate change just to offer a deeper understanding. Maybe not a whole course on climate change, but if there were something dedicated to the subject I think that would help." (Sam)

Joey, a secondary pre-service teacher, thought that creating lesson plans for a climate change unit would be beneficial.

- "It would be really cool to make lesson plans [about climate change]. I think that helps everyone. I already have a whole physics unit made because I've already had to take the time to make that. I would be comfortable and trust myself to take what I've already made because I put so much work into it." (Joey)

Similarly, other students mentioned having more support regarding how to incorporate climate change topics into lessons.

- "Learning how to teach it and when to teach it and when it is appropriate." (Peyton)

Rory, a secondary pre-service teacher, talked about having more valuable classroom experience and getting comfortable speaking about topics like climate change with a group of students.

- "It's mostly a matter of practicing. We don't get a ton of practice aside from a sample lesson here or there fielding student discussions. We're normally a guest

somewhere so it's not like [the students] are super comfortable talking to us about things. I don't think there's a good way to simulate or replace the experience of actually having in depth discussions over time with your students, so I think that's a gap." (Rory)

Shawn, a secondary education major focused in integrated science, struggled with the lack of teaching-focused science courses for secondary teachers. Primary education majors focused in integrated science take specialized science courses for those in the teaching program, but this is not the case for secondary education majors.

- "I feel like we [secondary teachers] are kind of tossed into some of these obscure and hard [science] classes but we don't have physics for secondary teachers or biology for secondary teachers. So I feel like it would be best if we had those kind of classes and then we'd be able to talk about [teaching]." (Shawn)

Thinking ahead to when they are teaching in their own classrooms, all 13 pre-service teachers predicted various challenges that might arise when teaching lessons or activities about climate change. A primary concern that the participants had related to opposing opinions about climate change. Students mentioned bias, climate deniers, and misinformation as main issues they expect to come across when they are teaching about climate change.

- "The biggest challenge is that in our current system of education you have parents who bring their own personal views that might not be right into their children's lives and their children adopt those views and some of those views include people who don't believe that climate change exists." (Bailey)
- "The personal beliefs of students, what they come in already thinking from peers or family members. I think reluctance is something that would be tough to try and

overcome, both from students and parents." (Sam)

It can be challenging for teachers to talk about climate change with their students if they feel like they don't have support from their fellow teachers or superiors.

- "If there's students with their own personal beliefs or even a family's beliefs that they think that climate change is a hoax. Dealing with that, so I'm just concerned about will I have the support, 'cause if I'm teaching my class that this thing's happening and then they go to another class where that teacher kind of undoes my work and it confuses them. That's kind of my concern for the future." (Shawn)
- "Parents who don't believe it, or even your school district maybe, if you have a superintendent that doesn't believe in it that could trickle down." (Morgan)

Pre-service teachers also talked about the challenge of gaining enough knowledge about climate change to be able to teach using data and trustworthy information sources.

- "There'd be an uphill battle of fully understanding it before you try to relate it to your students." (Taylor)

Climate change has also become a controversial topic that can be emotionally-charged for many people, as well as a topic that is associated with politics. Some participants wondered how this would affect classroom discussions about climate change.

- "Emotion being a part of the conversation is something that makes it really hard to talk about casually." (Rory)
- "The sense of urgency that I have or the concern I have with [climate issues] gets dismissed as a political talking point so when that comes up I'm not sure yet how I will address that professionally." (Riley)

Bailey, a secondary pre-service teacher, spoke about the challenge and responsibility to expose

students to important topics so that they become interested and take action themselves.

- "You have to design a lesson or a series of lessons that make the subject interesting enough that it leaves a lasting thought process in them so they either go look it up themselves or like try to do something individually or as a school community about it." (Bailey)

To conclude the pre-PLC interviews, I asked the participants how they would integrate skills and content learned in their college courses into climate change lessons they would design for use in their own classrooms. These responses were coded as "Lesson Design" as described in Table 4. All participants related what they have learned in university courses to their future teaching plans; however, some participants had more concrete plans than others. Most of the participants brainstormed what kind of lessons they would want to teach to relate their content to climate change.

- "I think if you can take something like a natural disaster and scaffold that into talking about how they become more prevalent as the climate changes." (Sam)
- "I would [use] a lot of models to show on a smaller level [that] this is what's happening in this model, [and] then try to get the students to think this is what's going to happen in the overall world basically." (Shawn)

Students also shared general, overarching skills and strategies that they learned in their college courses that they will incorporate into their lesson design moving forward.

- "Definitely the standards help because a lot of the science standards talk about the way humans interact with the Earth, so you can just literally take the standard and use it to help explain." (Jordan)
- "Make the content unique in how you approach it so that they feel excited to

come back and learn more about the content." (Bailey)

- "When you asked me what sources I get this from most I was kind of mortified. I don't know where I'm consuming my information. I think a stress on making sure that the sources you are using are validated and then making a point to be an active, engaged citizen to consume that information. Developing confidence in forming and sharing arguments based on what you learn and what you see and then learning how to better question and explore [are important skills]." (Riley)

Rory, a secondary education major, talked about the interdisciplinary nature of climate change topics and the benefits of combining topics that are traditionally taught separately.

- "Personally I think different aspects of [scientific disciplines] are too separate and unit-based so they're not always connected with other things that have already been learned. It's not fully integrated in a way that reinforces the knowledge that students already have. I think teaching from a more holistic standpoint can be a good 'in' for incorporating things about the natural world into other lessons that are normally thought of as discipline-specific." (Rory)

Joey, a secondary pre-service teacher, talked about the power of involving students in the decision-making process for what content they will cover.

- "Something that I like to do is make sure that you ask your class, 'We're going to talk about these things. Is there anything that you wanted to talk about?' So you'd ask them probably a month beforehand, 'other than what I've laid out, is there anything in there that you want to learn that maybe I can put in on a Friday or in an extra space?' and let them learn about things that they want to learn about as well." (Joey)

Jordan, an elementary pre-service teacher, shared how creating a classroom climate that values caring for the environment can be implemented in addition to formal lessons about climate change.

- "You could teach [that] in our classroom this is our culture and we are going to recycle our paper or everyone brings a reusable water bottle. Also doing hands-on activities that can relate to their actual world to show them that it's not just some crazy obscure topic, [but] that it relates to them physically and actually." (Jordan)

Closing Thoughts

At the close of the interview, I asked the participants if they had any other thoughts they wanted to share about climate change or teaching. Students who chose to share their thoughts reflected on the importance of climate change for them personally. For Shawn, this interview provided an opportunity to think about how to integrate climate change into future teaching.

- "I'm always trying to fight climate change but I feel like there's still a lot more for me to learn and I'm realizing that now through these questions that you asked me and I've never really thought about teaching and climate change. I know I want to get a message across but I never really sat and thought about it until now." (Shawn)

Jordan shared her concern for young students who will face the consequences of climate change and how this motivates her.

- "Just that it's so important and that I hope the other educators feel it's just as important because the less kids are ready to tackle this huge issue that we are leaving for them then that doesn't look good." (Jordan)

Post-PLC Interviews

After participating in the PLC, I conducted follow-up interviews with 12 students from CHEM 406/407 to see if the event had any impact on their climate change beliefs, their confidence communicating about climate change, or how prepared they felt to teach about climate change and related topics. To analyze the post-PLC individual interviews, I developed a list of qualitative codes. Some of these codes were used in coding the pre-PLC interviews, while new codes emerged due to experiences at the PLC. Each code and its description are given in Table 7.

Table 7

Descriptions of Qualitative Codes for Analysis of Post-PLC Interviews

Code	Description
Confidence/Comfort Level	Response describes how confident, comfortable, or prepared the participant feels about speaking or writing about climate change after participating in the PLC
Explanation of Changes	Response discusses changes, if any, in the participant's climate change perceptions or PLC assessments after participating in the PLC
PLC Experience/ Feedback	Participant shares about their experience at the PLC, including feedback on the event's activities
Lesson Design	Response discusses how the participant would design climate change lessons after participating in the PLC
Climate Change Solutions	Response offers potential solutions to climate change, in terms of climate change education and environmental protection
Informal Education	Response discusses sources of informal climate change education, including reading academic or social media articles, discussing with friends or family, or watching environmental documentaries
Formal Education	Response discusses formal climate change education that the participant received during K-12 or higher education

Each interview contained multiple codes based on the participants' responses to my prepared interview questions. The frequency at which each code emerged in the dataset is given in Table 8. All post-PLC interviews contained an elaboration on changes in confidence and whether or not the PLC caused changes in their climate change beliefs. The post-PLC interviews allowed participants to share their experiences at the event as well as gave the interview

participants the opportunity to offer any feedback on the content or organization of the PLC event.

Table 8

Qualitative Coding of Post-PLC Individual Interviews

Codes	Total Frequency (*N* = 12)	Percent of Total Responses
Confidence/Comfort Level	12	100%
Explanation of Changes	12	100%
PLC Experience/Feedback	12	100%
Lesson Design	3	25%
Climate Change Solutions	2	16.7%
Informal Education	2	16.7%
Formal Education	1	8.3%

As with the pre-PLC individual interviews, the analysis began with how comfortable the participants felt discussing climate change and the issues surrounding climate change after attending the PLC. Similarly, the participants shared how prepared they feel to teach about climate change after participation in the event's activities. Students then shared their general experiences and takeaways from the PLC. During these interviews, I had the opportunity to ask the participants about changes, if any, in their SASSY responses and any documented shifts from their confidence self-assessments. The participants also offered feedback on the content and organization of the PLC event. The analysis of post-PLC interviews concludes with closing

thoughts that students shared in regard to their climate change beliefs and thoughts on lesson design.

Comfort Discussing Climate Change

All 12 post-PLC interview participants discussed their comfort level in discussing climate change. A third of the participants did not feel like the PLC had an impact on their comfort level talking about climate change. Others felt that engaging in discussion and hearing from faculty members helped them to feel more comfortable speaking about climate change with others. Some students shared that they felt more comfortable talking about climate change, but still needed to do more research in order to feel knowledgeable about the subject.

- "I definitely feel a lot more comfortable and more knowledgeable about it. I think hearing other people's perspectives helped a lot." (Peyton)
- "I feel like I can maybe better express myself, but I still need to do research to back up my thoughts." (Avery)

Shawn, a secondary pre-service teacher, was inspired to act by the discussion of Greta Thunberg, a young environmental activist.

- "Especially with seeing how [Greta Thunberg]'s 16 years old talking to politicians who are acting totally mean to her and seeing that she's able to speak in front of hundreds of these people everywhere in the world and showcase her voice gave me more courage to speak up." (Shawn)

Blake, a secondary education major, made the point that being knowledgeable about the topic or having a science background does not mean you are confident in or have the skills to speak about climate change.

- "I realize that I have a larger science base but that does not necessarily make you

more effective or more comfortable in communicating with people." (Blake)

Teaching Preparedness

Similarly, I asked if the PLC event had any impact on the participants' level of preparedness to teach lessons or activities about climate change. All participants said they either experienced no change or felt slightly more comfortable teaching climate topics. The event's activities, especially the interdisciplinary discussions and faculty modeling, influenced students' confidence and comfort level.

- "I feel pretty confident. I think [the table discussions] helped me clarify things that I would verbally say out loud and things that I would actually do with kids." (Jordan)

When asked if any responses regarding their definitions of climate change, views on the global or personal impacts, or influential sources had changed since participation in the PLC event, two-thirds of the participants said the event had no impact on any part of their climate change beliefs. The remainder of the participants felt that their core ideas had not changed, but through the event they were exposed to new perspectives or felt that their beliefs were reinforced through conversations with peers from different disciplines.

- "I just got in different viewpoints but that's all that really [changed]." (Peyton)

Shawn, a pre-service secondary teacher, elaborated more on the influence of social media on his tablemates' climate change beliefs.

- "We all realized that the majority of us find out about climate change [through] social media and being online. We said if Kim Kardashian said something about climate change, a lot more people are going to be aware on that so realizing how big an influence on that." (Shawn)

Participant Experiences at PLC

During the post-PLC interviews, I asked participants to tell me about their experience at the PLC event. All 12 participants shared their experiences at the PLC and how the activities at the event impacted them. One common takeaway for the students was that climate change is an interdisciplinary topic and can be viewed from multiple perspectives.

- "People from different professions can look at climate change differently but come to the same conclusions." (Sam)
- "When I think of climate change it's a straight up thing, science. Now I think of science and politics and speeches and all that, so it has many layers now to me." (Shawn)

The experience at the PLC also allowed some pre-service teachers to think about how they would prepare to teach about climate change and incorporate it into their curricula.

- "The fact that they focused the writing on social media posts made it more relevant to a teaching scenario if you wanted to talk to your students. You could have them analyze Twitter posts and they would probably be comfortable with that." (Rory)
- "We talked about how we could raise awareness, so we could write letters to the State so that way students can voice their own opinions, and our students could become activists on it." (Shawn)
- "I think one big takeaway that I took from the Pop-Up is that science is ever-changing and so it's important to make sure you're keeping yourself updated with current data." (Charlie)

The PLC event prompted some reflection about challenges that need to be addressed moving

forward as educators.

- "Part of the problem that we're having with climate change or with the political climate in general is that we get polarized and reactive so we stop listening to one another." (Blake)
- "I felt like maybe it was challenging for people who don't have the majority opinion to talk about it because we never had someone say something different [during the table discussions]. It was kind of like pulling teeth getting them to engage in the discussion." (Jordan)

SASSY Changes Due to PLC Participation

After discussing students' experiences at the event itself, we talked about changes in their survey responses, including the SASSY and whether or not they believe taking action on climate change is a matter of opinion. The majority of the interview participants had no change in their SASSY responses before and after the PLC event. For those who did record a change, they were not sure why they responded differently and they did not feel that the PLC had any impact on the survey changes.

- "I'm not sure if it reflected much of a change per se or just the way I interpreted and answered the question." (Rory)
- "I'm really not sure why I would've flip-flopped like that. Nothing happened to change my opinion." (Sam)
- "It could have just been how I felt that day." (Taylor)

Confidence

As shown earlier in the results section, participants at the PLC event self-reported any changes in their confidence speaking or writing about climate change after participating in the

event's activities. All 12 of the interview participants reported an increase in confidence or no change. I asked the pre-service teachers to provide reasoning for what could have caused a change in their confidence.

- "I got to be more confident in my speaking abilities, [including] the ability to talk to other people calmly and effectively." (Avery)
- "I think collaborating with others and hearing opinions from other students was helpful." (Charlie)
- "Being able to verbalize what you want to say and get other feedback is super important because I have a tendency of spewing information and then I end up forgetting important things that I know." (Jordan)
- "I got better tools to support my arguments." (Bailey)

PLC Feedback

At the end of the interviews, I asked students if they wanted to provide any feedback about the PLC that they would want to change for the next iteration. Students wanted a heavier discussion of climate change facts, as well as solutions to lessen personal contributions.

- "Have more things about climate change. Maybe talk about ways to help climate change, how it happens, why it's doing it, the reason behind all of it." (Avery)
- "Maybe more facts [about climate change] or more helpful hints." (Morgan)

Several participants gave suggestions regarding how to revise some of the existing activities or ideas for changing the format of the event to become even more interactive.

- "I think [the communications exercise] could be a little bit more useful if we [could talk with students from] other fields of study." (Peyton)

- "Just to offer a little more question/answer back and forth, maybe questions and concerns the student body might have for the professors and just allow for thought processes to come out while also allowing the people at the tables to interact a little bit more." (Sam)
- "Personally, I thought it was going to be a workshop station kind of thing, where we'd go to one thing and maybe [have] two professors talking there and then I could say some stuff or do a little activity, so maybe that might be something more interactive." (Shawn)

Some students mentioned issues with the time constraints and how that impacted their experience at the PLC event.

- "The main problem was probably just the schedule being packed and there were a few things that had to get cut short. I think if the groups were a little bit smaller we'd be able to hear from everyone." (Rory)
- "I would say have more time because the first session we were rushing things because we started late." (Taylor)

The opinion was also shared that the event's leaders could be more transparent beforehand about the purpose of the event or the learning objectives for the participants.

- "I don't know that I left feeling like I was any better equipped or that the people at my table were any better equipped. I wasn't sure what the purpose of it was other than getting an idea of what people thought." (Riley)
- "It felt more like it was some sort of weird philosophical experiment where the teachers were getting experience in talking to people about climate change rather than it being something to educate people about climate change." (Blake)

Closing Thoughts

As with the pre-PLC interviews, I concluded by asking participants if they had any other thoughts they wanted to share about their experience with the PLC or anything else about their thoughts on climate change. Jordan, a pre-service elementary teacher, remarked that the event allowed her to use metacognitive strategies to reflect on her own thinking about climate change.

- "I like being able to [use] metacognition - think about my thinking. I think that throughout this the biggest thing that I will take away from it is taking a second to clear up my head, clear up my opinions, and scientifically think things through and be able to explain things verbally and on paper, be able to communicate with people [in a] more clear and organized way." (Jordan)

Three of the participants took the opportunity to share how the PLC impacted their thoughts on lesson design. One of these participants, Bailey, a pre-service secondary teacher, felt that the format of the PLC could be applied to other issues other than climate change and could benefit students from any discipline at EMU.

- "If our school did more stuff like [the PLC] for other subject areas it would be more beneficial to students because you can get a lot of different opinions in one room. If you took that kind of set up from climate change and did it for other classes and brought students to talk about it I think it would be beneficial for other people at the university." (Bailey)

Finally, Riley, a secondary education major, hopes to apply the idea of an interdisciplinary learning experience in the future by collaborating with other teachers.

- "I really like the idea of doing current events and things that our students can participate in and if we can do some kind of interdisciplinary block unit with

[teachers from other disciplines] maybe it would be more meaningful for the students. [The event prompted the question:] are we giving our students the information and the knowledge they need to make these informed decisions before asking them what their informed decision is?" (Riley)

Chapter 6: Focus Group Interviews Results and Discussion

The purpose of the focus group interviews was to ask another population of pre-service teachers what has influenced their beliefs and what would need to happen in order for them to change those beliefs. To analyze the focus group interviews, I developed a list of qualitative codes based on participant responses. These codes and their descriptions are given in Table 9.

Table 9

Descriptions of Qualitative Codes for Analysis of Focus Group Interviews

Code	Description
Evidence	Participant discusses how scientific evidence has informed their climate change beliefs and would be needed in order to change their beliefs
Formal Education	Participant shares how their formal education in K-12 or college has influenced their climate change knowledge and beliefs
PLC Experience/ Feedback	Participant discusses their experience at the PLC and what could be changed to improve the event
Social Reaction/ Social Media	Participant talks about how the overall social response to climate change has informed their climate change beliefs or concern, whether through the reaction of their peers in person or through social media
Solutions/Efforts to Change	Participant discusses what they believe must be done in order to combat climate change, whether through education or changes in behavior
Weather/Natural Events/ Environmental Quality	Participant shares how weather events, natural disasters, or overall quality of the environment has impacted their climate change beliefs
Religion/Ideology	Participant discusses how their religious beliefs or ideology impact their climate change beliefs
Family Influence	Participant shares how parents or other family members have influenced their own climate change beliefs

Code	Description
Media	Participant discusses the influence of the media's treatment of climate change on their climate change beliefs
Miscellaneous Response	Participant shares personal thoughts tangentially related to conversation about climate change beliefs
Personal Concern	Participant discusses how their personal concern for animals or future generations informs their beliefs about climate change
Politics	Participant describes the influence of politics on their climate change views

Each focus group interview contained multiple codes based on the participants' responses to my prepared questions. Due to the nature of focus group interviews, students were able to respond to each other and build off one another's responses. The frequency at which each code emerged in the dataset is given in Table 10. The frequency of each code is given for each type of focus group (Alarmed/Concerned and Cautious/Dismissive) as well as the overall frequency in order to demonstrate any differentiation in frequency across focus groups.

Table 10

Qualitative Coding of Focus Group Interviews

Code	Frequency Alarmed/ Concerned (*N* = 9)	Frequency Cautious/ Dismissive (*N* = 4)	Total Frequency (*N* = 13)	Percent of Total Responses
Evidence	9	3	12	92.3%
Formal Education	3	4	7	53.8%
PLC Experience/Feedback	1	4	5	38.5%
Social Reaction/Social Media	5	0	5	38.5%
Solutions/Efforts to Change	5	0	5	38.5%
Weather/Natural Events/ Environmental Quality	5	0	5	38.5%
Religion/Ideology	1	3	4	30.8%
Family Influence	0	2	2	15.3%
Media	1	1	2	15.3%
Miscellaneous Response	1	1	2	15.3%
Personal Concern	2	0	2	15.3%
Politics	0	2	2	15.3%

The focus group interviews yielded responses in three different categories of codes. The analysis begins with what has influenced the participants' climate change belief and transitions into what would be needed for the participants to alter the beliefs that they currently hold. The focus group interview analysis concludes with a discussion of the focus groups' closing thoughts, especially in regard to their experiences at the PLC. Each of these sections contains data from both Alarmed/Concerned groups and the Cautious/Dismissive group.

Influences on Participant Climate Change Belief

For students with SASSY designations of Alarmed and Concerned, the main influence on their climate change beliefs is what they have experienced in regard to weather changes, natural events, or overall environmental quality. Five Alarmed/Concerned participants discussed these environmental phenomena in their focus groups.

- "I would say just the experiences of severe and changing weather that's been happening in our country, especially along the coastal areas. It just seems different and more catastrophic than things that have happened in the past."
- "I would say all of the different wildfires that aren't usual in different places."
- "I've been to a couple big cities and the air quality is definitely very different compared to even here."
- "Going up to Cleveland you can't see the tops of buildings because the air quality is so bad there and it's very noticeable especially in bigger cities like that."
- "Seeing what's happening in bigger cities, especially in China where they have air masks that they have to wear because it's so bad."

Five students also mentioned the social reaction to the potential consequences of climate change that caused them to reflect on the importance of this issue, as well as social media and environmental campaigns.

- "What I see with my peers and how concerned they are and all the protests, that's kind of what makes me take a step back, and think, 'okay maybe this is something to be concerned about.'"
- "I would say a lot of the people that have opinions that I really trust have been saying that this is happening."
- "I personally really care about animals and the ice caps melting and the effects that I see happening with polar bears and penguins and the fact that their habitat is being destroyed at a rapid rate really concerns me."
- "I follow a lot of things on social media that are posting a lot about it. It's also the same with my political views, the people I follow are very forward about climate change, so that's how I get my information."

The focus group participants also noted the importance of checking the validity of the articles that they consume.

- "Social media pops up articles but then I go and make sure that it was scientifically factual."

For students with SASSY designations of Cautious and Dismissive; however, the primary influence on their climate change beliefs relates to their religious background and personal ideologies. Three out of the four Cautious/Dismissive participants described how their religious beliefs inform their thoughts on climate change.

- "I am Baptist, so a lot of my beliefs have come from what I've learned through my parents, through church, and by reading the Bible. That's my main influence."
- "I'm Christian. I don't really worry too much about all that stuff about climate change because I just have trust. It comes from my beliefs."
- "There's portions of the Bible that say we're to be stewards of the Earth, but it wouldn't be my job to say you need to also have that same exact belief and do that same exact thing that I do."
- "The idea that the change we're seeing is mostly from humans, I don't believe that we have that kind of control over what's happening to the climate. I believe that there's a higher power that's a little bit more in control than just us being able to save the world. It's good to do what we can but in the end, I believe there's a higher power that will make sure that things will be restored."
- "Through growing up in the church and being surrounded by those people and always reading the Bible, I know the Earth has cycles."

Students in the Cautious and Dismissive group also talked about needing unbiased evidence that climate change exists and is human-caused.

- "I personally haven't heard a lot of strong evidence toward climate change. It's more just, 'oh this horrible thing is going to happen if we don't do this,' but I need more evidence to actually support it."
- "I've seen a little bit of evidence, especially the carbon dioxide levels, so I'd say I'm gaining more knowledge about it so I do think it's a little bit important to pay attention to."

The Cautious and Dismissive participants said they have had classes that briefly talk about climate change data and related environmental issues but feel there has not been a strong enough focus on climate change in order for them to see enough evidence to believe anthropogenic climate change is occurring. These students also felt that the controversial nature of the conversation prevented teachers and professors from bringing up the subject in class.

- "I feel like they can't go deep enough so we can actually talk about it and that they can give us their opinion and more evidence on it because I don't think anybody wants to start an argument."
- "It's unfortunate because it's kind of a polarizing thing so I think teachers are very cautious on how they bring it up."

What Is Needed to Alter Climate Change Beliefs

In the latter half of the focus group interviews, I asked the participants what would need to happen in order for them to change their climate change beliefs. When asking Alarmed and Concerned students what they would need in order to believe that anthropogenic climate change is not occurring, all nine students responded that they would need strong scientific evidence.

- "I would like to see some long-term research that indicates that the things that we're seeing aren't alarming or new or catastrophic, that they're simply a part of a bigger cycle. I would have to know that what we're seeing and what we're experiencing is 'normal' and not something that we're causing with our practices."
- "I can't really think of anything that could change my mind unless it's really strong evidence, 'cause there's already so much strong evidence showing that it is happening."

- "Just some really hardcore evidence countering the argument of everything that we do believe is causing it right now."

For Cautious and Dismissive students, faith-based support was of utmost importance for them to change their climate change beliefs.

- "It [would have to] be backed up by my beliefs, because that comes first to me. I believe that science and God go together. I don't think they're separate. I would want the evidence to line up with Christian beliefs and Biblical beliefs."
- "My beliefs are very important to me. I'm not the type of person to compromise those beliefs and so in order for me to believe that climate change is happening there would have to be some sort of evidence that lines up with my beliefs."

To better understand these responses, I asked the participants how they would know that the scientific evidence was aligned with Biblical or spiritual beliefs.

- "I feel like one way could be someone who I know is actually a Christian and actually believes these things and so they're credible in that sense but then they're also credible in the science field."
- "Because I believe the Bible is true, evidence would have to line up with the Bible."
- "They probably wouldn't have to be a spiritual leader, but they would have to be able to back it up with Scripture exactly."

Unbiased scientific research, or what this group of students perceives to be unbiased research, was also needed in order for them to believe that climate change is happening.

- "I'd like to see a good study that would support that which was not funded by political parties. A lot of the studies out there I've seen have traced roots back to

the funding being from a political activist or something, so if we could find something that would be solely isolated and just science."

One pre-service teacher felt that in order to know that humans are impacting the Earth and contributing to climate change, they would need to see change as a result of action.

- "I think climate change is always happening. For the more, 'is it human-caused?' maybe if there was drastic action taken to help stop what scientists and popular culture and everybody's moving towards, like 'oh we need to save the planet' maybe if there was change from that I'd be like 'oh maybe we are causing something.'"

Closing Thoughts—PLC Experience and Feedback

As with the individual interviews, I closed the focus group interviews by asking the participants if they had any final thoughts. The common theme for Alarmed and Concerned students was that taking action on climate change will only benefit the Earth, regardless of if anthropogenic climate change is actually occurring.

- "It doesn't hurt to try to make positive change. There's no harm in being concerned and trying to have good practices when it comes to our planet, even if this isn't quite as severe a dilemma as some seem to think of it as."
- "If [climate change] is not real, then we're still making the Earth a better place. That's something that even if it's not real, why are people upset about us wanting to change our way just to make the world better, even if it's not affecting the environment as much as we think?"

- "We should be doing things to better the Earth. There's no harm to it. It could cost, that's always a thing, but we live here. Why not try to make it better for everybody?"
- "The things that the scientists are asking us as citizens to do, like stop using as much plastic and non-reusable things, what's the harm in that?"
- "It's not a problem that happened overnight. It's not a problem that's going to get fixed overnight. Just making the smallest steps we can, even if they seem insignificant, make a good impact and it's inertia. Start gettin' it going and it's just going to keep on going, so. Gotta start somewhere."

At the end of my interview with the Cautious/Dismissive focus group, we talked about their experiences at the PLC event and whether or not they felt comfortable sharing their beliefs with the people at their tables.

- "I don't think so. I could tell that it would have gotten heated if I had brought up what I thought. I interjected some points and thoughts, but I didn't full out tell them what I believe."
- "I felt comfortable telling them my very basic beliefs about climate change, but not going into depth of why, because religion can be a very heated topic with people so putting those two together in that sort of environment where you're sitting at a table with people whose beliefs are completely opposite yours, that can get really heated really fast, especially when you're not familiar and necessarily know the people you're sitting with."

- "There were a couple people at my table who were super opinionated, so I just knew it probably wasn't the place to do that. I'm kind of an introvert. I don't usually just go and talk to random people, so I didn't feel comfortable sharing."

Because the group conceded that they did not feel very comfortable talking about their climate change beliefs at the PLC event, I asked them what they thought would be a better setting for a conversation of this nature. This question also prompted some general feedback for the Pop-Up Learning Community.

- "Something like this [focus group interview]."
- "Put people with similar beliefs at a table so that you feel comfortable freely talking about your beliefs and not worrying that the conversation could get really heated because somebody has that opposite belief."
- "I think it was fine putting people together who had different beliefs and this would be hard but if there were enough manpower to maybe have a moderator at each table just to keep it calm."
- "I get the point of having different beliefs at one table because you want to be able to learn from other people and not just be stuck in your own head, but I think it's also good to be aware that people won't share as often, so maybe if there was somebody there, like a staff member or something there, to facilitate the conversation and if no one's talking to bring up something else to talk about 'cause it got kind of silent at some points."

Chapter 7: Conclusions

The SASSY showed slight increases toward higher levels of concern for climate change and increased likelihood of taking action. Personal importance of climate change to the participants yielded a statistically significant shift toward greater importance after the PLC event's activities. Evidenced through the individual interviews; however, many students could not explain changes in their SASSY responses from pre-PLC to post-PLC. The PLC event did not cause any discernible impact on any changes in the participants' SASSY responses. In future iterations, it would be helpful to give participants the opportunity to explain their answers to each question in order to accurately gauge the impact of the PLC event on their survey answers.

After the event, the PLC participants reported statistically significant increases both in speaking and writing to others about climate change. Participants pointed to the event's activities, including written response to a social media post and a communications exercise, as benefiting them in their confidence. Collecting data to explain changes in confidence would also be appropriate for future iterations.

The pre-service teachers who participated in individual interviews shared their definitions of climate change, what they view as the personal and global impacts of climate change, and how they will bring climate change and related environmental topics into their own teaching. The interview participants held basic scientific definitions for climate change that were influenced by formal and information education, social media, and politics. Concern for future generations was a common theme throughout the interviews as it relates to elementary students and the participants' offspring having to manage the consequences of climate change. The participants shared what challenges they think they will face when teaching about climate change. Facing pushback from students, parents, or colleagues; not having a full understanding of the mechanics

of climate change; and integrating climate change topics into lessons were the primary challenges that pre-service teachers foresee when bringing climate change into their classrooms. Based on the interview data, teacher preparation courses would benefit from an increased focus on environmental lesson planning. Additionally, some secondary pre-service teachers voiced interest in having content courses with a specific teaching focus, parallel to courses like "Chemistry for Elementary Teachers."

Designing climate change lessons was thought to be a challenge for many of the pre-service teachers that I interviewed. Despite the fact that many of the participants had not thought about how they would teach about climate change prior to the interview, many were able to think of ways they could integrate environmental topics into their curricula. Students mentioned the use of models or making lessons more interdisciplinary so climate change could connect more easily to other science content.

The focus group interviews, also with pre-service science teachers, provided insight into the value of scientific evidence for students of opposing climate change beliefs. Both Alarmed/Concerned students and Cautious/Dismissive students would need to see unbiased scientific evidence in order to change their stance on anthropogenic climate change. However, these two groups define and understand unbiased evidence differently. Alarmed/Concerned students view current climate change research as valid and rely on this data to inform their climate change beliefs. Conversely, Cautious/Dismissive students believe that the current data is politically skewed and want to see evidence that is not funded by political groups. Cautious/Dismissive students said they would also need this evidence to align with their Biblical worldviews in order to believe that human-caused climate change was occurring.

The student reflections submitted after the PLC showed that the event was effective in

helping students practice skills learned in their general education courses. Participating in the PLC made students feel more confident in their beliefs and abilities due to the interactive nature of the activities. Students also shared that the faculty modeling helped them to see that climate change can be discussed using different lenses and that climate change arguments can be analyzed from multiple perspectives.

This very realization was one of the biggest takeaways from this study for me, as a researcher. The event caused many students to come to the conclusion that climate change is an interdisciplinary issue. As evidenced by reflections and interviews, many participants thought that climate change was a scientific issue exclusively and that students of other backgrounds may not be equipped to have an intelligent discussion about issues of climate change. However, through faculty modeling, interdisciplinary table discussions, and other experiences at the PLC event, students realized that they have skills and content that are valuable to the conversation around climate change. For many, the PLC was an empowering event that allowed students to practice speaking and writing about climate change with others, regardless of their climate change expertise. Some students had similar "lightbulb moments" in realizing that the skills they learn in their general education courses can be applied outside of the classroom. Many students expressed through their reflections or in the interviews that they plan to carry what they learned in the PLC—and in their college courses—on into their professional and personal lives. Making these connections was a goal of the PLC and it was satisfying to see how impactful the PLC experience was for many of its participants.

In planning another iteration of the PLC, the organizers can take into account student feedback that came from reflections and interviews in order to make changes to the format, alter existing activities, or design new activities to incorporate into the sessions. All feedback and

suggestions for future iterations of the PLC have been compiled in Appendix E. Involving students from additional disciplines should also be a consideration for the next PLC event. It would also be interesting to bring scientific data and facts about climate change into the event to see if there would be more changes in SASSY responses after scientific evidence is introduced. In future PLCs, it will be useful to better understand what about the event influenced student confidence in speaking and writing about climate change.

Chapter 8: Future Work

I am particularly interested in continuing to learn more about the influence of religious and political beliefs on climate change beliefs. I was able to hear from the participants of one focus group interview that personal religious beliefs are the main contributing factor to why this group does not believe that climate change is occurring and human-caused. I would like to engage with this topic further to understand how religious beliefs influence students that do believe that anthropogenic climate change exists.

I would also be interested to follow up with my CHEM 406/407 individual interview participants once they are teaching in their own classrooms to see how they have incorporated climate change or environmental education into their instruction, if at all. In addition to lesson design, I would want to hear from them what challenges they have faced with their students, colleagues, or parents regarding bringing climate change topics into the classroom.

I hope to work with more pre-service teachers in the future and interview them about their thoughts on other complex scientific issues that may come up in their classrooms. If possible, I would like to conduct these same climate change interviews from this study with a new population of students from a different institution to see any changes in climate change beliefs.

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APPENDICES

Appendix A: List of PLC Organizers and Staff

PLC Event 2017

Danielle Clevenger, MA student, philosophy

Evan Dority, PhD, philosophy

Amy Flanagan Johnson, PhD, chemistry

W. John Koolage, PhD, philosophy

Katherine Ryker, PhD, earth science

Tim Ward, MA student, communications

PLC Event 2019

Danielle Clevenger, PhD student, philosophy

Evan Dority, PhD, philosophy

Katherine Greenwald, PhD, biology

Amy Flanagan Johnson, PhD, chemistry

Vee Kennedy, MA student,

W. John Koolage, PhD, philosophy

Rachelle Marshall, PhD student, education

Dave Pawlowski, PhD, physics

Nick Romerhausen, PhD, communications

Katherine Ryker, PhD, earth science

Lauren Williams, MA student, philosophy

Meagan Winkelseth, MA student, communications

Appendix B: IRB Approval Letter

EASTERN MICHIGAN UNIVERSITY — University Human Subjects Review Committee

Aug 5, 2019 6:41 PM EDT

Mary Engfelt
Eastern Michigan University, Chemistry

Re: Exempt - Initial - UHSRC-FY18-19-332 Climate Change Instruction in Higher Education: Pre-Service Teachers' Engagement in an Interdisciplinary Pop-up Learning Community

Dear Mary Engfelt:

The Eastern Michigan University Human Subjects Review Committee has rendered the decision below for Climate Change Instruction in Higher Education: Pre-Service Teachers' Engagement in an Interdisciplinary Pop-up Learning Community. You may begin your research.

Decision: Exempt

Selected Category: Category 2.(ii). Research that only includes interactions involving educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior (including visual or auditory recording). Any disclosure of the human subjects' responses outside the research would not reasonably place the subjects at risk of criminal or civil liability or be damaging to the subjects' financial standing, employability, educational advancement, or reputation.

Renewals: Exempt studies do not need to be renewed. When the project is completed, please contact human.subjects@emich.edu.

Modifications: Any plan to alter the study design or any study documents must be reviewed to determine if the Exempt decision changes. You must submit a modification request application in Cayuse IRB and await a decision prior to implementation.

Problems: Any deviations from the study protocol, unanticipated problems, adverse events, subject complaints, or other problems that may affect the risk to human subjects must be reported to the UHSRC. Complete an incident report in Cayuse IRB.

Follow-up: Please contact the UHSRC when your project is complete.

Please contact human.subjects@emich.edu with any questions or concerns.

Sincerely,

Eastern Michigan University Human Subjects Review Committee

Appendix C: Six Americas Super Short Survey (SASSY) with Response Options

1. How important is the issue of global warming to you personally?
    - Extremely important
    - Very important
    - Somewhat important
    - Not too important
    - Not at all important
2. How worried are you about global warming?
    - Very worried
    - Somewhat worried
    - Not very worried
    - Not at all worried
3. How much do you think global warming will harm you personally?
    - A great deal
    - A moderate amount
    - Only a little
    - Not at all
    - Don’t know
4. How much do you think global warming will harm future generations of people?
    - A great deal
    - A moderate amount
    - Only a little
    - Not at all
    - Don’t know

Appendix D: Social Media Post from PLC

A close friend sends you a personal message with a link to a new article about climate change from Buzzfeed. Below are their comments to you about it:

I just can't believe this article!!!!! Why can't the authors understand that we are destroying the planet that our children are going to live on? Don't they care about their kids? And it isn't like it'll be that hard to make the necessary changes. If we all just drove electric cars and became vegans things would be SOOOO much better. Do you remember how hot it was in late September of 2017? Nearly every city in lower Michigan had 6 days straight of 90+ degree weather! Don't even get me started on the polar vortex in January 2019! What did we miss at EMU, like 6 days of classes over two weeks? Clearly this is evidence that we have a major global crisis on our hands. Either we take decisive action now or we and our planet are going to die because of this. Climate 👏 change 👏 is 👏 real. 👏

Appendix E: Compiled PLC Feedback and Suggestions from Participants

Reflections:

"I would say that I would have liked to really define and objectively talk about more climate change points as it felt like to me the students there from philosophy or physics did not have the background to really talk about the subject as objectively as they wanted to. I also had kind of hoped to have the denial claim being made, while the opinions were not the same totally the consensus was in agreement and that doesn't allow us to see what data or influences leads one to deny this scientific base and I feel like that would have been a good conversation point."

"I didn't know that there was going to be assigned tables, which forced me and my peers to have a controversial conversation with essentially strangers."

"In the pop-up learning community, I expected to learn more about the actual science behind global warming. The PLC leaders seemed to assume that we all had a general understanding of climate change, and already had strong, formulated opinions."

"If I were to criticize one thing, it would be the end of the event. When the professor was talking about the morality thing, I was confused with what he was talking about, and then when we broke into the improv groups, I wasn't sure what we were supposed to be doing and neither did anyone in my group. I wish the event ended in a stronger way."

"Participating in the Pop-Up Learning Community was beneficial to my confidence about talking

about the topic, but I wish it would have been more informative on the topic global warming."

"I thought that we were going to talk about how global warming more in depth, and how to change it. I thought that the information was good, but I don't think that it was enough to do something about. I hope that the next one will be more in depth with what actions we can do to help it."

"The time constraint during the PLC made the aspect about communication skills run short and that seemed underdeveloped."

"I wish we had more time to really dive into the discussions, because a couple of group members who were more extroverted led the conversations and I noticed there were 2-3 people who didn't say much of anything unless directly asked."

"I especially liked how the program began and ended with the same activity to see if we had any changes that we could then visibly see."

Individual Interviews:

Avery: "I think the first thing would be to have more things about climate change. If you're going to say 'oh it's about climate change,' then actually - I saw in the Pop-Up lesson the videos of the little girl, they were kind of out of context, because I didn't know anything about her, I had heard in it in the news, but I didn't go research her before we watched the two-minute clip, and

so then I was kind of lost. So I was like, ‘what does she have to do with it?’ Well then, come to find out that she’s an advocate for it, and I think that’s great, but I think lessons, like how to present it ‘cause I know that was a big group of people, not all educators, so I understand that people are not there for lessons, but maybe talk about ways to help climate change and how it happens and why it’s doing it and the reason behind all of it.”

Bailey: “I think the only thing I would really talk about because I wrote it in my reflection is that it would be beneficial to have people play devil’s advocate, kind of like Blake did with the questions when one of the professors was asking questions like ‘well would you kick a puppy?’ and Blake chose to play devil’s advocate because the point is he wanted to get the response and I think it would be interesting in that sense to have some people be assigned to choose to be the denier of the claim and have some data in a sense that supports their claim. Obviously it wouldn’t be correct because it’s not really a supported science, but I think it would be interesting to have it so when you’re talking and there are people not agreeing with your point and they’re talking about their point and then it becomes the expertise value, which is kind of what this became, is [that] you’re taking your expertise and using it to talk to others about it so I think that would’ve been interesting. That would’ve made it longer, unfortunately. I think it would be interesting to get Pawlowski to talk because I think everyone there had good expertise facts to talk about and I agreed with everything that they were saying because they were bringing up points that they were experts in and [that] made sense to me, like ‘I support this and no one will say you’re wrong’ but I think having someone like him, or at least a physics professor that is an expert in something like atmosphere would be an interesting counterpoint to some of the points that were brought up to say what of their background supports what they say or what they don’t

say. None of them really supported what anyone said, unfortunately, but it would be interesting to get different other backgrounds, too. I think those were really the only points that I thought could be changed because I did like how everything else was because you have your table and then obviously the goal was to split the table up as much as possible which I think worked pretty well and we also took the tables and talked to other tables. I thought that worked pretty well. We only had two hours for everything and I think in the time frame you had a lot of stuff that normally you would've done, but you got through a bulk of things that were good and there was not anything we were really behind and had to rush through it and I think we got to try everything and listen to a lot of stuff, but I think you can add more time there'd be a lot of stuff you could add to make it more interesting."

Blake: "I don't think so. You guys actually had a lot of bases covered. I think that at the end, the reflection and the tiny.urls and stuff like that for the finale could be communicated more effectively. So if that means that you have little tear off notes that you say "please fill these out" or something like that going out the door, that would be good because either people missed it or I didn't write it down or something like that and it became the exercise for the professor that you were adjoined to to tell you what to do and that's just another thing to work so if you can have that going on, and maybe a little checkmark next to it be like 'oh I did this,' that would probably be helpful. You'd probably get responses back a little bit earlier too, maybe a week earlier. So. There you go. But otherwise, not too bad. Thank you."

Charlie: "Because I didn't get to go to the original [PLC] - I guess it's not changing what you guys did - but just having multiple perspectives is I think something super important because in

the real world you get that, so it's kind of nice to have a round table of it and have that experience before you get out there and have to deal with it on your own [laughs]."

Jordan: "I don't know a better way to get people to talk or to come out of their shells a bit. I feel like maybe a way without trying to exploit people but have them have an index card with their opinion on there or something they stick with and that way they have something that's physical, like this is my opinion, this is my belief. That way when it comes to group discussions or stuff like that they can't just be like 'oh yeah I agree.' They have what they know, because I feel like a lot of people's opinions and views just didn't get heard because of majority opinion or because they were afraid of getting judged or because of whatever, so I feel like if they had something that they had to stick with maybe that would make it a little bit better. Or if they felt like there [were] more people who viewed their opinion because I felt like a lot of the other people who maybe had their opinion also didn't say anything and were just saying 'yeah we agree too' so they felt probably alone [laughs]."

Morgan: "Like I said, maybe a little bit more - I don't know why, but I was expecting it to be more factual, like pieces of, I don't know. I guess facts [about climate change] or more helpful hints or something along those lines, but I guess with talking with your group, we all pretty much felt the same way about things."

Peyton: "I signed up to go to the earlier section but then something happened and I went to the later one - which they said was completely fine - but the group I was in was mostly [from ethics] and they were underclassmen so they didn't really care and they didn't really know what to do or

say so I would think having maybe a little bit more variety of age group because I'm in my last year of college so I feel like I already have a lot of knowledge and I've already been to one of these so I also knew that, but having people more comfortable with the dynamic of it so they can feel comfortable and actually know what to talk about. Also I think the thing at the end where we did the lines could be a little bit more useful if we -I felt like I just kept talking to the same type - ethics and chemistry - I never feel like I got into the other fields of study so I think that would've helped a lot."

Riley: "I liked that the tables were mixed, so it wasn't like you could come in and sit where you wanted to sit, because I would have sat probably with other science students and we would have had more similar backgrounds. I liked that it gave us the opportunity to kind of dialogue answers that we might give in a conversation or situations we might meet when we're meeting with family [laughs] or other individuals that might have different ideas. I think the only part where I kind of got stuck was answering the entering and exit questions just because they were so black and white - so it's either, they affect you greatly, they affect you somewhat, they don't affect you, you're neutral, or whatnot. I think I would have liked a little bit of an in between. Because when I decide well do I think it affects me greatly? Personally maybe not. I come from a place of privilege but the fact that it affects other people does affect me. I would have maybe expanded upon that a little bit. Other than that I also liked that the Pop-Up involved faculty from different departments and different ideas there and that when I sat down they said I was sitting with people with different opinions, which for me was shocking. [laughs] I was like, 'oh, here it goes, I'm going to embarrass myself right here' but it didn't happen which is good. We did the exercise where there were prompts about 'someone at your dinner table says this, A B and C,

what do you respond to that with?' and that was kind of fun practice. I don't know that I left feeling like I was any better equipped or that the people at my table were any better equipped. We didn't give them resources to look at or ways to further it, although I suppose maybe having a discussion would encourage them if they wanted to go out and look on their own, too. Maybe leaving there I wasn't sure what the purpose of it was? Other than getting an idea of what people thought. I wanted to register some people to vote and they didn't want to vote and things like that, so I was like 'well what did I do, I didn't really do any good,' but maybe there's good in just learning it."

Rory: "The main problem was probably just the schedule being packed and there were a few things that had to get cut short and it kind of started a little bit late so that didn't help. I don't know, maybe the order of things, so maybe it was more… I don't know. I liked that there was the before and after writing to the same thing to see if there is a change in opinion just from having conversations. I think that was a good way to bookend it. I'm not great at event planning, so I don't know how it would be better to change the activities or the schedule for them, but it just seemed a little bit tight. Also, I don't know what was up with the seating at my table, but there were two-tables worth of people. [laughs] There were too many people for the seats assigned to sit there so it made it a little crowded and then people had to move to a random other table, stuff like that. I think if the groups were a little bit smaller we'd be able to hear from everyone, but other than that I think everything you did was reasonable and it made sense why it was in there."

Sam: "Yeah, just to offer a little more question/answer back and forth, maybe questions and concerns the student body might have for the professors and just allow for thought processes to

come out while also allowing the people at the tables to interact a little bit more, which we did, but I kind of felt like we were all there because we feel like climate change and global warming is an issue so I felt like we were all boxed up from the beginning and there wasn't really much...not arguing, well I guess arguing, but there wasn't much difference in opinion. And, like I said, the people that I suspected maybe had a difference of opinion weren't very vocal about it, or they could've just been shy. And some people I heard were there for extra credit, so I think they were just trying to do that. I don't know if it was the correct way to get people to come in. I wanted to go in because I wanted to, but then once I started hearing people, 'well I'm just here for the extra credit, can we leave now?' sort of thing, I felt like they weren't there for the right reasons so probably weren't offering strong enough opinions, I guess. So I would change that. And scrap the communicating part at the end [laughs], just because - Yeah, where we went through different scenarios and stuff, I just thought that was poorly executed and I don't know if it was just not well thought up in the beginning or what. But I just felt like that was a waste of twenty minutes. So I would change that for sure [laughs]."

Shawn: "I don't want to say it should be longer, but sometimes it felt like we focused on some things for a while and I feel like we only hit maybe a few things and I feel like it could have been - Personally, I thought it was going to be a workshop station kind of thing, where we'd go to one thing and maybe [have] two professors talking there and then I could say some stuff or do a little activity and then go to the next one and all that stuff, so maybe that might be something more interactive. It was interactive, but sometimes it was just like you're sitting there and going through the PowerPoints and whatnot. So, I don't know, maybe standing up and walking around would've been a little bit more fun, but I still enjoyed it. Yeah, so it could be the same time

thing, but just maybe jam-pack it to a bunch of activities and I guess one person couldn't go to all activities but could kind of bounce around to different ones, so I don't know."

Taylor: "I would say have more time because we did end up, because the first session we were rushing things because we started late and stuff like that, so a little bit more time so then if this happens we still have a little time. Because in the end we were like 'okay, we want to respect your time so we have to cut off' so making sure there's more time just in case things run longer. Because no one's going to be mad if they get out early. Everyone gets upset if you run late. I enjoyed like the group activities because I don't enjoy lecture - I'm not a lecture person, but it's something you have to do with all science - and I enjoy the group activities more because working face to face in a table group is easier than like 'okay let's talk as a room' and stuff like that."

Focus Group Interviews (Cautious/Dismissive):

What do you think would be a better setting to talk about your climate change beliefs?

- "Something like this [focus group interview]."
- "Doing the survey before and splitting up the tables based on beliefs."
- "Yeah, I was going to say put people with similar beliefs at a table so that you feel comfortable freely talking about your beliefs and not worrying that the conversation could get really heated because somebody has that opposite belief."
- "I think it was fine putting people together who had different beliefs and this would be hard but if there were enough manpower to maybe have a moderator at each table to be

like “hey that’s a good thought, but maybe let’s not use insulting language” or it wasn’t insulting, but just to keep it calm.”

- “Yeah, or having someone there to guide the conversation or something.”
- “Like this. Kind of like you’re asking the questions.”
- “I get the point of having different beliefs at one table ‘cause you want to be able to learn from other people and not just be stuck in your own head, but I think it’s also just good to be aware that people won’t share as often, so maybe if there was somebody there, like a staff member or something there, to facilitate the conversation and if no one’s talking to bring up something else to talk about ‘cause it got kind of silent at some points.”