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Santa Barbara

Agents of Change: A Mixed Methods Study Examining Teacher Preparation for Climate Change Education

A dissertation submitted in partial satisfaction of the

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in Education

by

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Macias, M**.,** Lucas, K., Nation, J., **Arevalo, E**., Marckwordt, J., & Harlow, D. (2019). *Magnetism, light, structures, and rotational motion: mixed-methods study of visitors engaging with four exhibits at a science museum.* Physics Education Research Conference Proceedings.

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ABSTRACT

Agents of Change: A Mixed Methods Study Examining Teacher Preparation for Climate Change Education

by

Erik Arevalo

The field of science education has historically focused on developing mastery of discrete content at the expense of scientific practices (Zeidler, 2016). This emphasis has shifted in recent years through a new vision for science education put forth in documents such as the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). New standards like the NGSS focus on developing well-rounded students by incorporating practices *and* concepts that accurately reflect the real-life work of scientists. However, these standards do not adequately consider the social-political and cultural perspectives of the students they are meant to serve. For example, if issues such as climate change are considered only as science dependent, students are not exposed to the impacts that climate change has on communities that are disproportionality those of color (Feinstein & Kirchgasler, 2014). Since preservice teachers are trained in their teacher education programs to teach the NGSS, they are not being adequately trained to address these perspectives as well.

In this study, I utilized an exploratory sequential design to examine how 66 preservice teachers reported being prepared and empowered to address social justice science issues, specifically climate change. From interviews with science education and climate change experts, I identified core ideas for climate change education and a developed a survey for

preservice teachers as a result. I then collected and analyzed teacher responses from the survey utilizing a framework that integrates key concepts from culturally empowering pedagogy, justice-centered pedagogy (Morales-Doyle, 2017), civic science education (Rudolph & Horibe, 2016; Levy et al., 2021), youth participatory science (Morales-Doyle & Frausto, 2019), and professional teacher agency (Priestley et al., 2016). Results from this study provide areas of focus for teacher education programs to consider in order to empower teachers to be agents of change to help develop transformative students. Implications from this study offer a framework for teacher education programs to utilize to empower teachers as agents of change and strategies for educators to utilize to support the development of their students as transformative individuals.

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I. Introduction

Anthropogenic induced climate change (ACC) is one of the most pressing issues facing the planet. Every successive report from the Intergovernmental Panel on Climate Change (IPCC) has confirmed that anthropogenic climate change is a significant factor, if not the sole factor, for a variety of induced changes around the world (IPCC, 2001, 2007, 2014, 2021). These changes include an increased occurrence of extreme weather events, such as heatwaves, hurricanes, and floods. The implications from ACC are not isolated to atmospheric events. People all over the world, most notably those that are already in vulnerable positions, are predicted to be adversely affected by ACC (Irwin, 2020). As ACC progresses, resources will dwindle and as a result, social inequalities that stem from present day systematic barriers will worsen. This will be further compounded by predicted human mass migration from regions of the planet that are left uninhabitable (Cai et al., 2016).

As such, ACC is a global issue that lies at the intersection of science and social concerns. In this regard, there are three potential approaches to apply to the issue of ACC. These approaches include ignoring it, managing it, or solving it (Irwin, 2020). Ignoring ACC would enable all the adverse consequences that have been predicted to be realized and could likely exacerbate social inequities. Managing ACC would include imposing higher restrictions on emissions and/or increasing taxes on fossil fuels. Actions such as these have already been taken as seen by different international and national policies that have been passed such as the 2015 Paris Agreement and the 2009 American Clean Energy and Security Act. Solving the issue would entail abandoning a carbon fuel driven world by ceasing all aspects of fossil fuel combustion. Considering these factors, solving the issue does not appear to be feasible. These considerations thus propels managing the issue as the direction most likely to succeed.

For our global society, we need to take actions that can mitigate ACC as well as implement adaptive behaviors in order to avoid irreversible changes to our global climate.

One approach to potentially enact actions towards adaptation and mitigation is to rely on education to inform the public about ACC, more specifically science education as this is where ACC has been historically addressed. The reason for this is that education has the potential to integrate cultural, societal, and environmental factors when presenting material related to ACC. This is key as it has been noted that integrating all three of the aforementioned factors is critical for presenting information concerning ACC (Rousell & Cutter-Mackenzie-Knowles, 2020). Additionally, by utilizing education, we can inform subsequent generations who are going to be the leaders and policy makers of the future on what a sustainable planet could be (Lee et al., 2015; Lee, 2013). As such, educative materials that are ACC related are necessary (Dalelo, 2011; Ekpoh & Ekpoh, 2011; Fortner, 2001; Kagawa & Selby, 2012; Papadimitriou, 2004). These materials may include assessments, curriculum supports for K-12 teacher education, and professional development for educators. Furthermore, support materials that can be utilized in informal spaces, such as a museum, are needed as well (Stephens & Graham, 2008).

For these reasons, it is essential to understand the field of climate change education (CCE) in relation to learner ideas, current research, and current practices to evaluate what emergent themes occur that can be integrated into current curricula within P-20 institutions (Henderson et al., 2017). Efforts to address and integrate aspects of CCE have been seen in large scale reform efforts such as the Next Generation Science Standards (NGSS; NGSS Lead States, 2013). The NGSS address ACC through the integration of content standards that ask students to consider topics such as the interactions among ecosystems and the

transformation of energy, among other areas. However, although the NGSS are able to convey the science behind ACC, the social aspect of ACC is not similarly addressed. Feinstein and Kirchgasler (2014) examined how sustainability, a key component of the social aspect of ACC, is approached by the NGSS. Through their analysis, the authors developed three themes that captured the approach of the NGSS. These themes conveyed that, as a whole, the NGSS need to have a stronger ethical component in their dimensions alongside their crosscutting concepts, disciplinary core ideas, and science and engineering practices. The reason for this is that if ACC is presented solely as an issue for scientists to worry about, students will have a harder time integrating the ethical and human component of ACC into their thinking.

Zeidler (2016) expanded on the notion that traditional science education practices are not enough to prepare students for a society that will be more and more dynamic in terms of its integration of science and contextual values. In his article, the author argued that as it stands science, technology, engineering, and mathematics (STEM) programs are formulated in an isolated manner. In this isolation, STEM programs and their related curricula exclude the cultural experiences of most of their participants. As a result, the author called for the integration of other disciplines such as sociology, ethics, and history into STEM programs. The reason for this is that only then can a truly holistic approach to science learning be implemented. Holistic was defined in the sense that science is not a truly objective endeavor and, by integrating aspects that have been seen as subjective, will allow for a truer sense of what the scientific process entails.

To continue, this integration includes issues that are embedded within ACC but are not commonly addressed within the science classroom. These issues include a focus on social

justice issues that are centered on inequity, racism, and colonialism as these are influenced in part by the consequences of ACC. As such, it is critical to evaluate ACC in the context of frameworks that integrate a critical perspective of these influences. Frameworks such as culturally responsive pedagogy as initially described by Ladson-Billings (1995) and later expanded on by Paris (2012) can provide an initial basis to evaluate these issues. Furthermore, considering new frameworks, such as the one presented in this study, can additionally provide new insights through a focus on student empowerment. However, a challenge remains when considering these issues within science education, as social justice issues are currently undertheorized within science education (Dimick, 2012). Furthermore, as science education is being further conceptualized as a discipline that needs to consider the unsustainable impacts of human activities on the planet (Mogensen & Schnack, 2010), new goals such as providing global citizenship skills to enhance the role of individuals to understand and address global issues have been described (Blandford & Thorne, 2020). Due to this, new approaches have been suggested within science education to meet these goals. One of these approaches is to empower students to be agents of change in their communities (Upadhyay, 2010). Through this empowerment, students within the science classroom can become transformative individuals who enact change in their communities (Morales-Doyle, 2015). These changes can be extended to global issues such as ACC and, as a result, provide an opportunity for science education to empower students to be agents of change against ACC.

This expansion of the goals of science education thus presents a challenge for science instructors. The challenges associated with meeting the historical goals of science education and the expanded goals simultaneously presents teacher education programs with the task of

preparing preservice teachers to be able to address complex issues such as ACC while considering social justice goals previously outlined. This task is further complicated by two issues: the apprenticeship of observation and the problem of enactment (Hansen, 2018). The apprenticeship of observation examines how preconceived ideas a preservice teacher brings into their classroom may impact their pedagogical approach. This notion of preconceived ideas and its impact on teaching has been examined in relation to ACC by Kunkle and Monroe (2019). In their study, the authors found that if a teacher had a more conservative worldview, they tended to have a negative outlook towards ACC. A conservative worldview is defined as a perspective that opposes the scientific consensus on ACC and communicates a sense that the climate of the planet is perpetually changing regardless of human action. The authors identified that this can be problematic, as if left optional, these teachers might not address material that presents the scientific consensus on ACC. The problem of enactment explores the issue that even though preservice teachers may understand research-based approaches to teaching, they still may struggle implementing those approaches if their site does not endorse these approaches (Windschitl et al., 2021).

This issue of implementation thus extends into teacher agency and how empowered teachers believe they are in enacting the approaches they are taught in their teacher education programs. As such, teacher agency has been examined before in different areas such as implementation (Taylor & Lelliott, 2021) and different facets of teacher agency (Molla & Nolan, 2020). More specifically, the concept of professional teacher agency (PTA) has been examined in conjunction with complex issues such as ACC (Borgerding & Dagistan, 2018) in order to support teachers in enacting ACC related curriculum. Most work has focused on supporting in service teachers through the use of professional development (Larkin, 2020).

For this reason, more work is needed in supporting preservice teachers in developing their agency towards issues such as ACC (Edwards, 2007). This need for more work examining preservice teacher agency has contributed to various issues, such as teachers avoiding addressing controversial science issues such as ACC (Nunez et al., 2012) or feeling uncertain about how to address similar global issues (Bryce & Gray, 2004). For these reasons, this study aims to add to the literature of preservice teacher agency towards sociopolitical issues such as ACC that consider a social justice perspective.

A. Introduction to Study

In this study, I investigated how teacher education programs can better support preservice teachers in exerting their agency to enact ACC curricula and principles. Following a mixed methods approach, I utilized a qualitative phase in conjunction with a quantitative phase to conduct this study. The qualitative portion of the study consisted of expert interviews that identified ideas that are core to climate change education. Next, the quantitative phase was conducted by utilizing the findings from the qualitative phase to develop a questionnaire that collected preservice teacher perspectives on how TEPs can better support them in enacting ACC material through a social justice lens.

As such, in this study, my research questions are as follows:

1) What ideas core to climate change education were identified by experts in the initial qualitative phase?
2) How did PSTs perceive their agency in addressing ACC in their future classrooms?
3) What content and supports in enacting climate change education did PSTs identify? In particular, how did these areas compare to the core ideas that experts identified and to the framework of transformative teaching of individuals?

This study utilized a framework, transformative teaching of individuals, that integrates culturally empowering pedagogy, civic science education (CSE; Levy et al., 2021; Rudolph & Horibe, 2016), justice-centered science pedagogy (JSCP; Morales-Doyle, 2017), and youth participatory science (YPS; Morales-Doyle & Frausto, 2019) as well as professional teacher agency (Frank, 2006; Moore, 2008; Rajala et al., 2016) to analyze the data collected from the qualitative and quantitative phase. Utilizing these frameworks and approaches, I conceptualized a construct that was used to develop and further refine the questionnaire. This construct was defined as teacher agency towards climate change education principles (TACC) and is discussed further in this study.

The analysis from this study reports on core ideas that were identified from interviews conducted with experts from the fields of climate science, policy, education, and outreach among others. I also report finding about preservice teachers' agency to enact ACC related curricula, in particular on what resources and supports preservice teachers require in order to enact such curricula. Furthermore, from the analysis and integration of the qualitative and quantitative questionnaire data, recommendations for TEPs to better support their preservice teachers in becoming agentic towards ACC related curricula are provided as well.

B. Organization of Dissertation

The organization of this study is as follows. In Chapter 2, I present the conceptual frameworks that guided this study, including civic science, social justice, youth empowerment, and professional teacher agency perspectives. In Chapter 3, I review the literature to situate this present study within the areas of teacher agency, the ideas and beliefs that teachers hold about anthropogenic induced climate change, and student empowerment within science education. In Chapter 4, I review the research methodology and context that

guided this study. Chapter 5 explores the core ideas that were identified from the expert interviews to answer the first research question. Chapter 6 focuses attention on the integration of preservice teachers' quantitative and qualitative data from their questionnaire to answer the second and third research questions. Finally, Chapter 7 discusses the results and limitations of this study; implications for teacher, teacher educators, and researchers; and future directions for research.

II. Conceptual Framework

The conceptual framework for this study is compromised of the integration of four different approaches to science education as well as a conceptualization of teacher agency, known as professional teacher agency, to support transformation. One approach is civic science education (CSE; Levy et al., 2021; Rudolph & Horibe, 2016), which emphasizes the civic purpose of education within the science classroom. Another is justice-centered science pedagogy (JSCP), which focuses on how issues of social justice can be at the center of science curriculum (Morales-Doyle, 2017). A third is youth participatory science (YPS), an approach that is centered around the role of youth in the generation of all phases of knowledge production within the classroom (Morales-Doyle & Frausto, 2019). Connecting all three approaches, is culturally empowering pedagogy, which is influenced and derived from culturally relevant pedagogy as described by Ladson-Billings (1995) and her colleagues (Paris, 2012; Bonner et al., 2018; Hollie, 2019). My conceptual framework integrates these four perspectives and extends key aspects of these approaches through the lens of teacher agency, with the goal of having teachers become agents of change, agents who then support their students in learning to be transformative individuals to address social justice science issues, like anthropogenic induced climate change, or ACC. To accomplish this, the following sections elaborate on each of these perspectives and identify key concepts that can be integrated into a framework that centers teachers as agents of change.

A. Culturally Empowering Pedagogy

To begin, I will outline how culturally empowering pedagogy has been derived from the literature that encapsulates and is related to culturally relevant pedagogy. From there I will

outline how culturally empowering pedagogy is embedded and provides ideas and principles to the teaching for transformative individuals framework that is utilized in this study.

Culturally relevant pedagogy is an approach to education that strives to facilitate integrative strategies that empower culturally diverse students. Culturally relevant pedagogy differentiates itself from traditional educational norms by moving away from a deficit perspective that positions diverse learners as lacking in some form to a perspective that embraces the knowledge that students have within their cultures and integrates it into the curriculum (Gay, 2000). This approach is transformative in the sense that it shifts away from the normative structures of education that have supported middle class European Americans and teaches to the cultural strengths and intellectual capabilities of various ethnic groups. By teaching in this way, culturally relevant pedagogy supports diverse learners by viewing learning from a position of success and not failure. Ormrod (1995) expanded on this notion by connecting learning to the development of self-efficacy. This conceptualization of self-efficacy, as described by the author, positions learning as a process that develops from a place of confidence, which can be nurtured through an approach like culturally relevant pedagogy. Additionally, culturally relevant pedagogy is an approach that can help deconstruct current approaches in education that ignore the rich cultural histories of the diverse groups within our society. For example, Pai (1990) stated that ignoring the history and cultural knowledge that has helped build our country has fostered, in part, the social injustices and inequities that are prevalent not only in education, but in our larger society as well.

Culturally relevant pedagogy is a theory that first gained traction after it was described by Ladson-Billings (1995). However, the theory that the author described in her article has as its

foundation the work conducted in the 1970s with multicultural education. For example, Abrahams and Troike (1972) elaborated on an aspect that any pedagogical strategy needs to consider, which is the orientation of the instructor. Orientation, in this case, signifies the perspective a teacher takes in relation to their diverse learners. They explained that teachers who embrace the cultural differences among their students and are able to build upon these differences as resources can be effective instructors for diverse leaners. Additionally, the orientation of the teacher also includes the beliefs of the instructor, where the instructor needs to be able to address their own ideas of what it means to be an instructor of diverse learners. This notion was expanded upon by Carlson (1976), who advocated for the cultural backgrounds of students to be integrated into education. This is due to the importance that cultural backgrounds play in almost all settings in our society, so the author argued that instead of being ignored in education, these backgrounds should be fully embraced in order to reflect reality. These considerations, among others (Cuban, 1972; Aragon, 1973; Forbes, 1973), were synthesized and condensed into a recommendation by Gay (1975), where the author conveyed that cultural content should be embedded into mainstream curriculum because a student's cultural background facilitates the transmission of knowledge by taking foreign concepts and situating them in familiar ideas.

Taking these ideas and others from anthropology (Au & Jordan, 1981; Mohatt & Erickson, 1981), culturally relevant pedagogy in its most popularized form was theorized (Ladson-Billings, 1995). This theory built upon conceptualizations of embedding student culture by having students' cultures not just accommodated but developed within a curriculum instead. Ladson-Billings (1995) named her theory culturally relevant pedagogy and defined it as a model that not only addresses student achievement, but also assists

students in reaffirming and further developing their cultural identity. Additionally, a key component of culturally relevant pedagogy is to develop the identity of students as agents of social change. Holistically, these three components come together to form the basis of culturally relevant pedagogy, which in its essence strives to produce students who can succeed academically, demonstrate and further develop their cultural competence, and foster an understanding and ability to critique existing social structures.

Academic success is integral to culturally relevant pedagogy as it is to any educational theory, but with culturally relevant pedagogy, academic achievement is essential because of the deficit perspectives associated with preceding approaches to multicultural education. These perspectives positioned diverse learners as an "other" that needed support in order to allow them to conform to the norms of mainstream schooling. Culturally relevant pedagogy, however, positions academic success from a perspective of wealth, where learning for students mirrors more of a mining process that extracts the knowledge that students come into the classroom with (Freire, 1974). Cultural competence for culturally relevant pedagogy balances the seemingly conflicting goals of academic success and cultural wellbeing. For example, Fordham and Ogbu (1986) noted a phenomenon with diverse learners who succeeded academically in traditional classrooms. This phenomenon positioned diverse learners as individuals who were conforming to the dominant culture in order to succeed in the classroom. As a result, these students were perceived by their peers to be refuting their cultures in order to conform to classroom expectations. This disconnect is addressed in culturally relevant pedagogy by explicitly noting that in order to enact this approach, the instructor has to provide students opportunities to succeed while maintaining their cultural identity. Lastly, culturally relevant pedagogy 's third component is what provides a unique

perspective to enacting pedagogy. This component emphasizes helping students understand the social inequities that are perpetuated by social norms while developing their ability to critique these inequities as well. With this third component, culturally relevant pedagogy strives to develop students who are empowered with the knowledge to succeed within academia, but also who are able to apply their knowledge to create social change at any level.

To complete her conceptualization of culturally relevant pedagogy, Ladson-Billings (1995) offered the characteristics of teachers that are able to effectively enact culturally relevant pedagogy. These characteristics are a conceptualization of self that aligns with the goals of culturally relevant pedagogy, a pedagogical disposition to facilitate the social aspect of learning, and a conceptualization as to what constitutes knowledge of value in the classroom that aligns with culturally relevant pedagogy. The conceptualization of self is centered around the notion that the teachers who will enact culturally relevant pedagogy view their students as capable learners who can succeed in the classroom and also view themselves as part of the community they are working with. The social aspect of learning is also an important aspect to consider for teachers of culturally relevant pedagogy. The reason for this is that classrooms that are culturally relevant position students and teachers as social makers of knowledge in that the knowledge that each individual brings into the classroom is valuable. In this way, the classroom promotes an environment of cooperation rather than competition. Lastly, for teachers of culturally relevant pedagogy, the manner in which they value knowledge is integral as well. For example, if an instructor conceptualizes knowledge as strictly that which is derived from traditional assessments and bookwork, then culturally relevant pedagogy strategies are going to be rendered ineffective. If knowledge is valued

through traditional means, then the pedagogical strategies attempted will not be assessed with the proper lens.

The rich work that has been conducted within culturally relevant pedagogy and its extensions has provided many key concepts and principles to integrate into other frameworks. This integration led to the development of culturally empowering pedagogy. The development of this framework focuses on the addition of student empowerment to sustain culture. This focus on empowerment provides an anchor for academic success, the development of cultural competency, and an avenue to enact a critical lens. The development of this framework was in response to a call for the continued development of pedagogical approaches that focus on culture as a tenet of education (Ladson-Billings, 2014).

Culturally empowering pedagogy address this call by continuing to develop how culturally relevant pedagogy and its subsequent iterations can be viewed within the classroom. The empowering aspect of culturally empowering pedagogy extends beyond being relevant and sustaining, by placing students as agents of change that not only see themselves propelling their culture but immersing their community within their culture as well. So, in this way, students can enact changes within their community due to seeing their community as an extension of themselves. Culturally empowering pedagogy is not meant to replace the relevant or sustaining aspects of other iterations of similar pedagogy, but is meant to integrate a new key piece into these previous conceptualizations of a pedagogy that has culture as a tenet of education.

Frameworks such as civic science education, justice-centered science pedagogy, and youth participatory science all integrate in some capacity the ideas, approaches, and values of culturally relevant pedagogy that were described above. However, this study utilized

culturally empowering pedagogy due to the focus on empowerment that it provides for this study. Additionally, the focus of empowerment allows CSE, YPS, and JCSP to be integrated with one another to form the TTI framework.

B. Civic Science Education

One of the goals of science education is to prepare individuals to encounter and be able to interact with science-related issues in their lives. Policy documents such as *Science for All Americans* (author, 1989), *Taking Science to School* (author, 2007), *and A Framework for K-12 Science Education* (NRC, 2012) all make references to the need to have a public that can understand science at some level in order to be able to participate in the discussion of science-related civic issues. As such, the area of civic science education (CSE) has been highlighted as a means to begin to address this need (Rudolph & Horibe, 2016). CSE has been defined as the "educational experiences that support individual's ability to understand, explore, and take informed action on public issues related to science" (Levy et al., 2021, p. 1054). Broadly, CSE can be considered as a combination of subfields that examine the engagement of individuals with science-related issues. These fields include socioscientific issues (SSIs; Zeidler, 2003), science, technology, & society (STS; Solomon & Aikenhead, 1994), citizen science (United States General Services Administration, 2020), environmental education (EE; Stapp, 1969), and education for sustainable development (ESD; UNESCO, 2021), among others. These respective areas all integrate some aspect of civic life, science, and education in their central frameworks. As a result, the tenets of CSE are these aforementioned factors.

Civic life is concerned with the interactions that members of the public have with public matters. Levine (2007) expanded on this point by elaborating on how civic engagement with

public matters is done by influencing public structures through different actions. These actions can include voting, contributing financially to candidates, or volunteering with community organizations (Berger, 2009). The connection of civic life to science-related issues stems from the intersections of the actions of civic engagement to the use and production of science knowledge (Levine, 2007). The use of scientific knowledge describes how using scientific knowledge can help an individual make a decision related to a public concern. These public concerns can include issues related to public health, safety, or the environment. The production of science knowledge describes how the public has a prominent role in deciding what issues receive funding in the scientific-knowledge production enterprise. This is accomplished by electing public officials that allocate funding to scientific agencies such as the National Science Foundation. In this way, the issues that the public deems as important in science will receive the funding to advance our understanding of these issues. The science aspect of CSE refers to a conceptualization of the definitions provided by Wilson (1999) and Rudolph (2014) of what science entails. As such, science not only entails knowledge about the natural world and the systemic manner in which we research that world, but also the social processes that interact with that world as well. Lastly, education as defined in CSE is described as the experiences that enhance and support an individual's interactions with science-related public matters (Levy et al., 2020).

These definitions of the components of CSE lead to the primary activities that CSE attempts to enact in the classroom. These activities include foundational, exploratory, and purposefully active experiences. Foundational experiences within the classroom focus on the development of knowledge, skills, and values that are related to the science issue of choice. As such, foundational experiences focus on what has traditionally been the content of the

subject area of the classroom. Exploratory experiences are those that involve having students engage in the practices of science. These experiences are those that are described in the Next Generation Science Standards (NGSS) science and engineering practices (SEPs; NGSS Lead States, 2013). Among these SEPs are practices such as analyzing and interpreting data, developing and using models, and engaging in argument from evidence. Purposefully active experiences involve those that allow students to experience active participation within the public sphere (Llewellyn et al., 2010), for example, raising awareness about a science-related issue either through doing community work or by talking about the issue within their own classroom. These active experiences may be tailored to different goals and may result in a student being a monitorial citizen (Schudson, 1999), occasional citizen (Leydet, 2006), or a personally responsible citizen (Westheimer & Kahne, 2004).

Outside of the foundational components of CSE, there are other issues to consider when implementing this approach to science education. For example, considering the role and dynamics of power within the issues (Foucault, 1972) or how the process of uncovering the objective truth can be used to perpetuate social injustices (Gregory & Miller, 1998) are factors that could be integrated into CSE. This integration of the pillars of CSE and external factors can then lead to fostering emancipatory forms of knowledge (Habermas, 1971). These forms of knowledge support and encourage students to question the power structures within their current reality as well as having them consider how institutional forces may limit their participation in democratic life. Having students be able to develop these kinds of knowledge is critical as current standards, such as the NGSS, make no explicit reference to issues such as the sociopolitical forces that influence the sciences (Morales-Doyle et al., 2019). This lack of explicit reference leaves room for current standards such as the NGSS to be further

refined. Additionally, as mentioned in Rudolph and Horibe (2016), culturally relevant principles are another avenue to explore when it comes to enacting CSE in the science classroom. However, currently CSE offers key themes alongside other pieces that can be integrated into a framework that considers how to approach curriculum in the science education classroom, including a focus on civic engagement and a focus on the use and production of scientific knowledge.

C. Justice-Centered Science Pedagogy

Science education is a field that needs to integrate and continue to theorize how social justice can fit into the research that is conducted within it (Maulucci, 2012). The reason for this is that the inequalities that are tied to education are rooted in social justice issues that must be addressed in the classroom, including the science classroom. By being able to prioritize social justice issues in the science classroom, social transformation can be set out as a goal in education – to address social inequities in the contexts in which they occur (Barton, 2003; Duncan-Andrade & Morrell, 2008). As such, a framework is needed that can address the integration of social justice issues in science education. One such framework is justice-centered science pedagogy (JCSP; Morales-Doyle, 2017). In their framework, Morales-Doyle (2017) described the influences of two transformative pedagogies that focus on social transformation through the use of education. The first is culturally relevant pedagogy as described by Ladson-Billings (1995). In her work, as stated above, Ladson-Billings (1995) identified the central tenets of culturally relevant pedagogy as students being able to experience academic success, maintain and develop their cultural competency, and develop a critical consciousness through which they challenge existing social inequalities in our society. This idea of developing a critical consciousness is similarly described by Freire

(1970), through the process of conscientization. Conscientization is mediated through praxis, or the process of reflection upon the status quo of the world in order to transform it.

Drawing on these two influences, JCSP attempts to use social justice issues within the science classroom as a "means to disrupt the historical function of schools as producers of social inequality" (Morales-Doyle, 2017, p.1036). More specifically, JCSP utilizes social justice science issues (SJSIs) within the science classroom. SJSIs are similar to but distinct from socioscientific issues (SSIs) as described by Sadler (2004) through the explicit integration of the contextual and political nature that surround these issues (Cammarota & Romero, 2014; Stovall, 2006). Due to this integration, SJSIs are tied to generative words and themes, in which the words are derived from the themes. These generative themes are social justice issues that are embedded within the local context of the community. The generative words are derived from the themes because the words are the feelings and thoughts that arise from the students when interacting with the themes. The words allow the themes to be anchored to the students through the connection to their affective domain and their reality.

JCSP additionally positions students as transformative individuals who are capable of developing and leading social movements that aim to enact social transformation (Romero, 2014). This transformation is supported through the perspectives that students, most notably students of color, can bring when they are integrated into the production of science knowledge. As current perspectives in science are based off of western values, integrating the perspectives of students of color can provide the basis for enacting change to the social inequalities that are currently in place (Bang et al., 2013).

Using this framework, Morales-Doyle (2017) presented a case study that highlighted how JCSP can be utilized in a science classroom that historically covers content with traditional

pedagogical approaches. Utilizing interviews, student-submitted artifacts, and archival data, the author examined how JCSP was able to be used as a framework for a project that had an issue of environmental justice as its focus. This project, known as the soil project, attempted to understand the impact of two closed coal power plants on the soil contamination that was found in the local community. The findings from the study presented how the soil project was described by the students as an issue of environmental racism, the commitment to equitable academic expectations and achievement, and the development of the students as transformative intellectuals. Using environmental racism as a generative theme, the students were able to recognize the value of their work and the importance of understanding the domain specific content of the SJSI. Through the author's analysis, evidence was collected that noted the achievement of the students in a traditional sense. This included success in meeting expectations as defined in the NGSS and Advanced Placement (AP) exams for the content area. Lastly, the students were recognized as transformative individuals by their community. This was done through the students being able to present their findings at a community town hall alongside scientists. In this way, the students were recognized by their community and other scientists as experts within their community and as individuals who leveraged their knowledge in service of their community. The case study presented by the author provides a template for what key themes can be utilized from this framework in future iterations.

D. Youth Participatory Science

Social movements have had a lasting impact on our society by enacting change or bringing to the forefront issues that have been suppressed. For example, the "March for Science" movement began in response to the attack that science as an institution was

receiving during the last U.S. administration. Federal agencies, such as the Environmental Protection Agency (EPA) and the Center for Disease Control (CDC), were positioned as institutions that were guided by information collected through unreliable means. In response to this, members of the March for Science movement stepped out in support of science and the processes it undergoes in order to provide evidence for their recommendations. Through the use of demonstrations and social media outreach, the movement was able to advocate for science and was able to be a force in providing support for evidence-based policy making. Similar movements, such as Black Lives Matters or Undocumented and Unafraid, provide additional examples of social movements that brought national attention to issues of social injustice. These movements are similar due to their impact and focus on systems of inequalities and are tied together due to being led and driven by members of the youth community. In addition to being driven by members of the youth community, one of the key reasons why these movements have had widespread success in communicating a message and inciting social change is due to the influence that critical pedagogies have had on the movements (Cammarota & Fine, 2008; Payne & Strickland, 2008). This influence stems from the alignment of social issues with the goals of critical pedagogies. To elaborate, critical pedagogies attempt to position students as agents of change who have a critical perspective that can allow them to consider how current institutions potentially perpetuate inequities. As such, critical pedagogies can support students to be leaders and members of social movements. Furthermore, by having a goal of students being agents of change within social movements as mediated through critical pedagogies, equitable learning outcomes can be supported in the science classroom as well (Philip & Azevedo, 2017). As such, connection

between critical pedagogies and youth-led movements provides an opportunity to more closely examine how this connection can be utilized in the classroom.

In order to further explore this connection, Morales-Doyle and Frausto (2021) proposed a framework that examines the potential of members of the youth community, including students, as agents of change. The framework is labeled as Youth Participatory Science (YPS). This framework attempts to counteract the dominant ideology in science education that views learning through a learn-to-earn lens (Morales-Doyle & Gustein, 2019). This is conducted by YPS prioritizing equitable and meaningful opportunities for students to learn science by recognizing that students from marginalized communities have unique insights to offer. By integrating methods that challenge traditional assumptions about knowledge production (Bang et al., 2016; Weinberg et al., 2018), YPS shifts away from learn-to-earn to a community perspective of knowledge that does not position any dominant ideology of knowing over another.

To explore this framework further, Morales-Doyle and Frausto (2021) elaborated on how each of the core aspects of YPS contributes to a goal of developing students to be transformative individuals that can be agents of change. The focus on youth in YPS emphasizes that members of the youth community have and can continue to make contributions to intergenerational struggles for social justice. By recognizing the value that students bring to the classroom, new perspectives can be brought in that are embedded in the views and values of the individuals who are going to apply and utilize the knowledge to be taught (Tuck & Yang, 2018). The participatory aspect of the framework highlights the need for youth to be empowered and heard in all aspects of knowledge production. This goes beyond the participation that has been outlined in other participatory frameworks, such as

youth participatory action research (YPAR) or citizen science, by allowing students to disseminate research as well. Lastly, the view of science that YPS considers is one of acknowledgment of the role and history that the content of the science classroom has had in the persistence of various forms of oppression.

Through these core aspects of YPS, the framework attempts to extend and integrate other frameworks such as the 5Es (Bybee et al., 2006) and praxis (Duncan-Andrade & Morrell, 2008). This integration has led YPS to be guided by a cycle that allows the focus of the science classroom to be shifted away from disciplinary reproduction toward social transformation. The cycle consists of the following: define a social justice science issue, apply a scientific lens, plan and conduct an investigation, analyze data, and assess learning, followed by reflect, disseminate, and act. This cycle is not in a prescribed order as it allows the flexibility to incorporate the needs of the classroom by being able to be commenced at any point in the cycle. Using this cycle, Morales-Doyle and Frausto (2021) argued that YPS can encourage students to critique and recognize the interconnectedness of the enterprise of science and oppressive social issues as described by Vossoughi and Vakil (2018) in order to foster social change that is led by students.

E. Teaching for Transformative Individuals

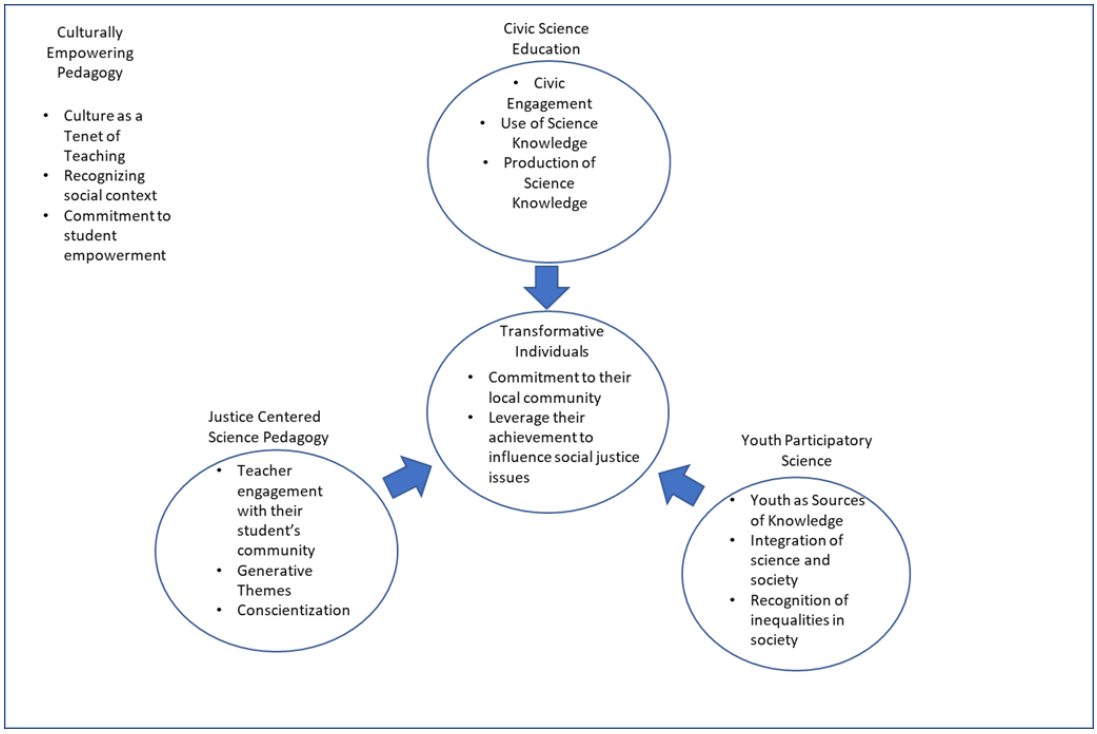
The four frameworks described above all have integral principles and ideas to consider when the goal of science education is to develop and support agents of change for social justice science issues, in particular, for ACC. As such, the current framework that has guided this study is described as follows. The framework is labeled as Teaching for Transformative Individuals (TTI) and has been developed by integrating key ideas from the frameworks that were examined previously (Figure 1). CSE, JCSP, and YPS all provide ideas and practices

that can be utilized in the context of culturally empowerment pedagogy. The culmination of these frameworks is to develop students as agents of change in the form of transformative individuals as described by Morales-Doyle (2017).

This framework provides principles that can be utilized in the science classroom by teachers when addressing SJSIs, particularly ACC. CSE provides a focus on the civic aspect that transformative individuals need when attempting to navigate a political system that has historically underserved most people in society (Vestergren et al., 2017). Additionally, the inclusion of the use and production of science knowledge allows for the integration of traditional achievement standards, such as those outlined in the NGSS. JCSP and culturally relevant pedagogy highlight the need to develop a critical view in students as described by Freire (1970). This critical perspective allows students to be able to criticize and understand why certain structures in society perpetuate inequities, including education. YPS emphasizes the need to have the students in the classroom be co-creators of knowledge alongside the teacher. The reason for this is that by being allowed to co-create in the classroom, students are empowered to recognize themselves as knowledgeable individuals who can enact change. Lastly, culturally empowering pedagogy provides a foundation that connects the other frameworks together by emphasizing the commitment a teacher needs to have not only to their students, but to their students' community, context, and empowerment. The role of the teacher within this framework is critical as they are the individuals who facilitate these practices and principles. The TTI framework aims to develop transformative individuals who have a commitment to their local community by supporting students in their development as agents of change.

Figure 1

Teaching for Transformative Individuals



F. Professional Teacher Agency

One key aspect of the TTI framework as described above is the role and impact that teachers have in enacting the principles of this framework. As such, an integral portion of the conceptual framework of this study considers how teacher enactment of the TTI framework can be mediated through teacher agency, more specifically, professional teacher agency as conceptualized through an ecological perspective of agency. Professional teacher agency constitutes the second framework of this study.

Agency is a construct that has been examined with the purpose of giving meaning and purpose to choices, actions, and the factors that influence them (Charteris & Smardon, 2018). As such, various scholars have conducted work to attempt to theorize agency. In their article, Emirbayer and Mische (1998) provided a definition of agency as one that considers the interactions of three key elements. These elements are iteration, projectivity, and practical

evaluation. Each element is grounded within the temporal environment of an individual that leads to an action. For example, the iterative element considers the past of an individual and the learned behaviors and experiences that they have accrued throughout their lifetime. Projectivity connects actions to the future of an individual and considers how actions can impact future directions. Lastly, practical evaluation considers the present conditions and the possible trajectories as a result of action within this context. The authors noted their conceptualization of agency is mediated by how an individual views their temporal presence in relation to their agency, the importance of the elements in each situation, and the social and relational engagement of an individual with their environment.

This last mediating factor of the social and relational engagement of an individual is one that has received more attention in the context of agency. Ahearn (2001) expanded on this factor by providing a provisional definition of agency as "the socioculturally mediated capacity to act" (p.112). In this definition, the author reinforced the notion that agency is impacted and influenced by sociocultural factors that are embedded within an individual's environment. Additionally, by drawing on the work of Karp (1986), the author noted that, as a result, the actor and agent within an individual is impacted by the societal norms where they find themselves. The actor, in this case, is the actions from an individual that are rule-mediated and the agent, that enacts actions with the intent to influence their world. As such, agency is a construct that is malleable and shifts with the norms of the sociocultural environment that an individual is within (Bandura, 2006; Frank, 2006).

Drawing from these perspectives, Nieminen et al. (2022) highlighted how teacher agency can be utilized within the classroom, more specifically, how agency can be utilized by all teachers within their classrooms to facilitate effective teaching practices, such as providing

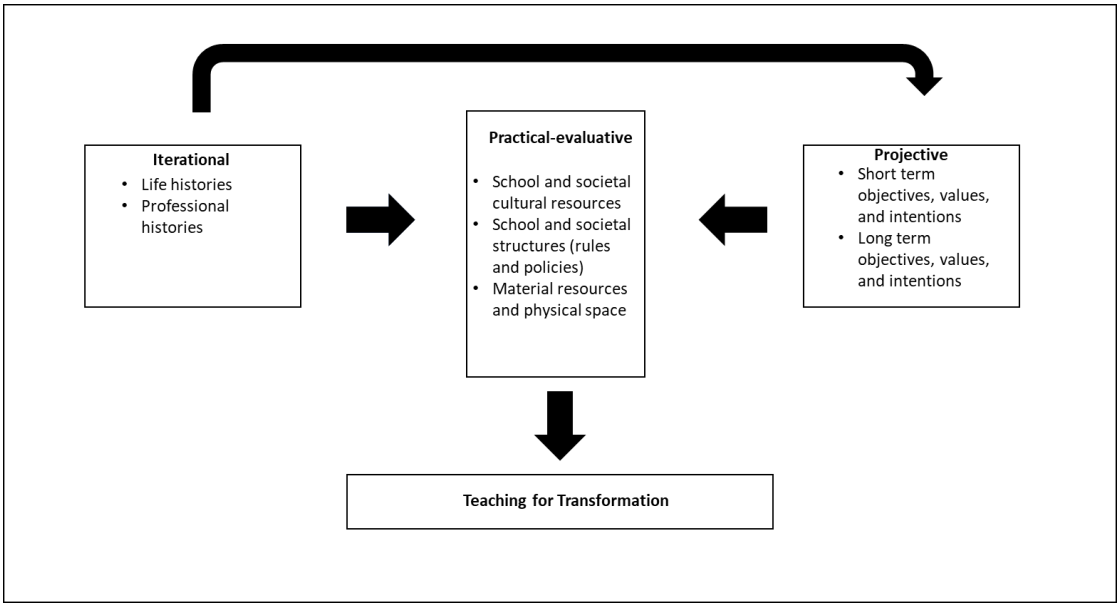
feedback to students. To facilitate these practices, the authors took the conceptualization of agency that integrates time, space, and the environment of an individual to mediate actions and applied it to the context of how students learn in the classroom. This agency was termed ecological agency as described by Biesta and Tedder (2007) and Charteris and Smardon (2018). Because the nature of ecological agency is a sociocultural approach versus a social cognitive approach (Li & Ruppar, 2021), ecological agency has additionally been used as a framework to contextualize teacher agency in the classroom (Lipponen & Kumpulainen, 2011; Martin, 2020; Maulucci et al., 2015). The reason for this is that a sociocultural approach conceptualizes agency as derived from the context an individual finds themselves in rather than an innate trait from an individual. In this way, it places responsibility for outcomes on the environment rather than as a direct fault of a teacher for non-actions (Priestly et al., 2015).

Using this perspective of agency, professional teacher agency (PTA) has been proposed as a manner to understand how teachers can enact change within the classroom. Additionally, PTA provides an understanding of agency that can be aligned with tenets of culturally empowering pedagogy, such as considering the perspective of a teacher and the beliefs they bring into the classroom. Figure 2 provides an overview of how PTA is constructed through the context of ecological agency by elaborating on the factors that influence teacher enactment through time. The past is represented through the iterational block of PTA where a teacher's beliefs and formative experiences influence their actions. The practical-evaluative block represents the present where a teacher weighs the present context to derive actions. The projective block represents the future and how the influence of the future and their desires for the future impact and drive their actions. These three temporal blocks influence one another

in intersection with the present environment that a teacher finds themselves in. By utilizing PTA, this study was able to examine how the preservice teachers reported the impact of factors that may constrain their ability to address SJSI, such as anthropogenic induced climate change (ACC).

Figure 2

Professional Teacher Agency



Note. Adapted from Priestley et al. (2016) and Li and Ruppar (2021).

G. Summary

Developing and supporting students to be transformative individuals – teaching for transformative individuals, or TTI – is a challenge that preservice teachers need support to learn and implement. Being willing to teach and knowing how to teach for transformative individuals are two key components of preservice teachers' agency to enact TTI in the science classroom. SJSIs have been noted as effective tools to reach the goals of TTI (Morales-Doyle, 2017), however, further work is required to better understand how TTI implementation aligns with constructs such as PTA. As such, this study sought to provide

insight into what supports and barriers preservice science teachers may encounter when attempting to enact PTA in the context of an SJSI such as climate change that is aligned with the TTI framework.

III. Literature Review

This study was grounded in the literature of three different areas within education that position teachers in the classroom as enablers of students as agents of change against issues such as anthropogenic induced climate change (ACC). As such, in this section, I first examine teacher agency by initially reviewing how agency has been conceptualized followed by how this work has been extended and examined within the context of teachers in the classroom. From there, I frame how the current literature of teacher agency is utilized within this study. Next, I briefly review the literature that has examined how teachers, both in-service and preservice, conceptualize and hold beliefs towards ACC to better explain how this current study fits into similar literature on the teaching of climate change in classrooms. Finally, I examine literature that has investigated how student empowerment has been examined within the science classroom. These examinations provide a context to how this present study aims to add to existing literature.

A. Professional Teacher Agency

Using an ecological understanding of professional teacher agency (PTA), different studies have examined how teacher agency is enacted by teachers and preservice teachers. In particular, Windschitl et al. (2021) explored how teacher agency can be impacted by the opportunities preservice teachers, or preservice teachers, may have in their training to enact research-based pedagogical approaches. The authors found that within most classrooms, preservice teachers are not provided many opportunities to influence their space and are caught in the middle between what they learned in their TEP and what is implemented in classrooms. This led the authors to further refine teacher agency as professional agency to

contextualize how certain actions or the absence of certain actions influence the professional agency that the preservice teachers were able to invoke.

This refinement of teacher agency as professional agency has also been explored in other studies. Birt et al. (2019) conceptualized teacher agency as professional agency to examine how STEM instructors negotiate barriers that they come across while trying to influence their environment. The authors found that to enact transformative actions that oppose reproductive tendencies, teachers must utilize personal and contextual factors such as their professional philosophy or classroom resources. This has been similarly found by Balgopal (2020), where the author reported that through the use of professional agency, teachers were more willing to enact actions that addressed problems that perpetuated the status quo at their sites. Their professional agency was found to be mediated by how heard and empowered teachers felt they were through factors such as mentor support and the connection to their community. This connection to community as an essential part of professional agency was also found in Martin (2020). In their study, the author elaborated on the role that relational practices have on professional agency. These practices include extending across content areas and outside the classroom as well as into the community of their students.

When examining PTA within the context of ACC, different studies have been conducted to examine the intersection of PTA and the enactment of ACC related curricula. For example, McNeal et al. (2017) examined the factors that led middle-school science teachers to utilize climate change education materials. From their study, the authors found that the agency middle school teachers had was mediated by their expertise on the subject, expectation of success, pedagogical philosophy, intrinsic values, utility value, and the cost value of teaching ACC. This led the authors to recommend that, in order to support teachers in enacting ACC

related material, teachers need to be empowered to see themselves as knowledgeable experts on the facilitation of climate change education instruction. This empowerment can be in the form of direct content instruction for teachers, the development of teacher support groups among teachers or with mentors, or support through the presence of a conducive environment. Drewes et al. (2018) explored empowerment though content knowledge by utilizing a case study that examined how a professional development unit assisted a primary school teacher in understanding ACC concepts. Through participation in the professional development unit, the primary school teacher was able to integrate their new content knowledge into their instruction by leveraging their own lived experiences. However, the authors did note that, while focusing solely on content knowledge as related to ACC can provide a sense of agency for teachers, it can propagate another issue. This issue is a de-emphasis on action towards ACC. As such, the authors noted that more work needs to be undertaken that examines how action can be derived from climate change education.

By focusing on the relationship between preservice science teachers and mentor teachers, Sezen-Barrie and Marbach-Ad (2021) explored how PTA towards ACC enactment is impacted by this mentor-mentee relationship. Through their work, the authors found that the feedback that mentors provided to their preservice teachers for enactment of ACC curricula was primarily composed of information related to the norms of education and science. These norms were composed of domain general scientific practices that reflected what scientists do in their work. Less reported was a focus on contextual factors such as community in mentor feedback. The implications for PTA indicated that if support is limited to feedback solely on the content of ACC, preservice teachers can potentially become constrained into thinking that climate change education is composed of only communicating science knowledge.

Tolppanen and Karkkainen (2021) found similar results when examining preservice teachers' views on the mitigative actions needed to combat ACC. The PSTs in the study were focused on a siloed view of strategies to mitigate ACC rather than on a systems thinking approach that is required for effective mitigation strategies. Findings such as these indicate that the agency that PSTs perceive they have can be constrained by a focus that is limited to their discipline.

Lastly, Maulucci et al. (2015) examined how to foster teacher agency through science professional development. The key finding the authors reported was that the environment that a teacher finds themselves in constrains teacher agency to be structurally reproducing or transformative. This led the authors to recommend that to support teachers in enacting their agency in transformative ways, teacher educators and professional development experts must consider how the present context of a teacher can be integrated into ACC related curriculum.

This focus on professional teacher agency has provided an area from which to further support teachers in their ongoing development as professionals, however, continued work needs to occur to understand how to empower teachers to utilize their professional agency to teach ACC. For example, most of the work that has been conducted examining professional teacher agency has been with the goal of addressing these issues within the context of professional development. While this provides in-service teachers the opportunity to refine their agency, it leaves the setting of teacher education programs as an area that has been underutilized. As such, by focusing on teacher education programs as places where professional agency can be fostered, preservice teachers can be provided with opportunities to cultivate their agency earlier. As a result, preservice teachers would be able to enter their

initial teaching positions better suited to negotiate their environment and be supported in their empowerment, voice, and autonomy (Molla & Nolan, 2020).

B. Teacher Conceptualization and Beliefs of ACC

As described above, PTA is impacted by different factors. These factors include the content knowledge a teacher holds about a topic they are going to provide instruction on (Penuel et al., 2007). As such, understanding how teachers conceptualize ACC is a key area to understand as teachers are expected to teach complex concepts such as the greenhouse effect, the Earth's energy balance, and the impact of fossil fuel combustion to students (Ekborg & Areskoug, 2006). Additionally, as students have many alternative concepts regarding ACC (Boyes & Stanisstreet, 1997; Koulaidis & Christidou, 1999), it is imperative that we understand how preservice and in-service teachers conceptualize ACC themselves. From this understanding, we can begin to design effective methods courses and professional development opportunities to address any inconsistencies in teacher thinking (Lambert et al., 2012).

From the literature, there have been many alternative concepts about ACC found to be held by teachers. For example, Plutzer et al. (2016) conducted a large-scale survey of middle and high school teachers and found that there was a large percentage of teachers who were unaware of the consensus that scientists have regarding ACC. In an early study, Dove (1996) examined student teacher understanding of concepts, such as the greenhouse effect, ozone layer depletion, and acid rain, through the analysis of a survey. The author found that these preservice teachers had a number of alternative concepts, such as that ACC is caused by a hole in the ozone layer, that global warming causes cancer, and that the greenhouse effect is caused by some barrier that traps heat. Ekborg and Areskoug (2006) found similar alternative

conceptions when they analyzed student teacher progress through a unit related to ACC. In addition, Papadimitriou (2004) analyzed a questionnaire to determine what ideas first-year student teachers had about concepts related to ACC. Alternative conceptualizations about the ozone layer and the role of pollution with ACC were found. These misconceptions were found to be prevalent again by Lambert et al. (2012) in their examination of preservice teacher progress through an elementary science methods course that was focused on ACC. Other alternative ideas found by these authors included the nature of the carbon cycle and the consequences of ACC. Lastly, in their review of the literature surrounding professional development related to climate change curriculum, Hestness et al. (2014) summarized the alternative ideas that are commonly found by both preservice and in-service teachers. These alternative ideas mirrored the ones stated earlier and included others, such as confusion about the difference between weather and climate, the impacts of ACC on the biosphere, and the role of other sources of energy on ACC. Given that teachers are the primary facilitators of information to students in the classroom and given that many teachers hold alternative ideas about ACC, additional research is warranted on how to effectively prepare all teachers to teach ACC concepts to their students (Liu et al., 2015).

Outside of the conceptualizations that teachers have about ACC, research has also examined teachers' beliefs about and implementation of curriculum related to ACC. Dawson (2012) conducted a study that investigated teacher ideas about ACC alongside their implementation of these ideas. The author found that teachers did have some misconceptions about ACC, as found in other studies; however, what the author also noted was that over a third of the teachers surveyed did not teach about ACC at all. A similar finding was reported by White et al. (2014); they indicated that roughly 20 percent of teachers surveyed in their

study did not address ACC issues at all in their classrooms. The teachers surveyed were a collection of agriculture, business, consumer sciences, language arts, math, science, and social sciences teachers. The authors noted that a key reason for this was that the teachers reported being constrained by factors such as time and available curriculum.

Other factors that have been noted to constrain or impede teacher implementation of ACC curriculum in their classrooms are teacher beliefs and emotions towards ACC (Hufnagel, 2015). Nation and Feldman (2022) conducted a study that examined teacher beliefs and its impact towards enactment of ACC instruction as well as the impact ACC's controversial nature has on any subsequent instruction. More specifically, the authors examined how teachers' beliefs influenced how they portrayed ACC as an issue as well as what pedagogical approaches they enacted because of that portrayal. The authors found that although the teachers in their study addressed ACC in their classrooms, they were hesitant about presenting the anthropogenic nature of climate change. The teachers wanted to avoid push back from stakeholders involved, such as administrators. This study presented a disconnect between the teachers' beliefs and their pedagogical strategies. The teachers self-identified as believers of ACC, however, they were hesitant about presenting ACC as an issue that has reached a scientific consensus. The authors noted that this presented an opportunity to further explore how to support teachers to fully address controversial topics, such as ACC, in the classroom. This support is important to consider here in the United States as studies conducted in other regions of the world have indicated that, if supported, teachers can fully address ACC. Such support includes being in favor of integrating social justice issues into the ACC curriculum and advocating for action-oriented pedagogical strategies (Howard-Jones, 2021).

In short, the beliefs that teachers carry with them, including their beliefs about ACC, impact their instruction. These beliefs are typically set by the time teachers start their first teaching position. As such, as noted in Luft et al. (2022), studies that examine how teacher educators can foster positive beliefs towards issues such as ACC are needed. The support and development of their beliefs can be addressed through professional development as well as within teacher education programs through courses or placements. In this study, I addressed this need by examining the agency PSTs perceived they had in enacting climate change curricula by considering the beliefs they had towards core climate change education ideas.

C. Empowering Students in Science Education

Within the science education literature, there has been a recent push to integrate concepts that traditionally have not been a part of the science classroom, namely student empowerment (Cebrian-Robles et al., 2021: Upadhyay et al., 2020). This has been done using different frameworks that center around agency, critical thinking, or beliefs and actions. Here I focus on frameworks that include both student agency and environmental justice. I discuss contextual factors, student beliefs, and a critical perspective as key components of student empowerment.

One key component of student empowerment is the consideration of contextual factors that students are a part of through their interactions with the environment. For example, Oliveira et al. (2015) examined how student empowerment can be fostered by exploring how environmental agency can assist students in evaluating the intersection of environmental issues and sociocultural factors. The authors defined environmental agency as the capacity to transformatively interact with social structures that are influenced by the environment. These interactions are understood as driven by meta-agentive discourse that is described as how

individuals talk about their actions, attribute responsibility, and describe their decision-making processes (Ahearn, 2012). Using this notion of environmental agency, the authors found different themes that they identified as being recognized by the students in the study. These themes included humans as agents of balance, imbalance, mitigation, and endangerment, among others. However, a key finding that the authors reported was the critical role of the affective domain in fostering a sense of empowerment among the students. They argued that the integration of rationality and emotionality provides a sense of connection that can ground a student's relationship with nature. This finding was also found in Singh (2021) in their analysis of a case study that featured a psycho-social component. This component highlighted the need to consider how the affective domain can drive students to dissuade or allow students to feel empowered towards ACC.

Another component of student empowerment is the beliefs that students hold towards the issues of interest and how these beliefs influence action. For example, Skamp et al. (2012) focused on the role beliefs have on empowering students to take proenvironmental action. To investigate this, the authors examined the beliefs that students hold about the effectiveness of proenvironmental actions and the connections about their willingness to enact these actions. Through the use of a survey, the authors were able to collect responses from over 1,200 students. From their results, different coefficients were calculated that indicated that students believed that different actions had varying impacts as well as having varying degrees of willingness to enact them. For example, students had strong beliefs that nuclear power, home insulation, and more recycling would help reduce global warming. These actions were found to have support as well in their willingness to act upon them. However, in general, the authors reported that the students' willingness to act was not aligned with their reported

beliefs on the impact of those actions. This disconnect was noted to be an opportunity to have the classroom be a space where beliefs could be aligned with actions in order to have scientific knowledge and social activism reinforce one another (Chawla & Flanders Cushing, 2007).

These findings on the disconnect between beliefs and actions were supported by the work of other researchers. For example, Rodriguez et al. (2011) found a disconnect between what students reported they believed in the effectiveness of actions with their willingness to enact them. However, the authors did note that through the use of education that explicitly addressed environmental issues and that considered the socio-cultural background of those issues, behavioral belief could be transformed into actions. Fisher (2016) further expanded on this through his work examining how current climate activists commit to their activities. Through the use of interviews, the author found that there were key factors that the activists described in their commitment to their activism. These factors included the emotional connection they had to the environment, their concern for social justice, their recognition that climate change is ceaseless and dynamic, and their commitment to a community and not just an issue. This culminated in the author recommending that presenting climate change as an issue integrated in nature and social justice is key. Additionally, a dynamic framing supports a commitment to climate change as perceiving ACC as changing with new developments keeps the issue centered in an individual's reality at a scope that they are comfortable with. The findings from this study presented targets for teachers to develop when empowering students to be agents of change, not only for ACC, but for other global issues as well.

Furthermore, Trott (2021) discussed how everyday actions can be utilized by children and youth to empower them to be climate activists. In their discussion, the author focused on

different areas that can be further explored and reconceptualized in order to facilitate student empowerment as climate activists. The first area is the current view of policy versus culture in education. This examination considers that culture should have more of an emphasis when considering policy so that instead of policy coming from a top-down approach, it can be holistically considered at all levels of policy formation. In this way, the cultural values of the people in the classroom will be reflected in policy and thus provide support over time for the enactment of the policies (Solnit, 2016). Next, the author called for issues related to ACC to be explicitly referenced and taught in the classroom to provide a foundational base for students to reflect on when considering the issues critically. Moreover, this should include addressing the political, social, and economic aspects of ACC instead of focusing on the issue as solely a scientific one (Feinstein & Kirchgasler, 2015; Rousell & Cutter-Mackenzie-Knowles, 2020). Lastly, the author explored how everyday actions by youths and children should be championed in order to empower and provide continued support for agency-building opportunities (Trott, 2020). As students have been shown to want to take action against climate change (Carlisle, 2021), supporting teachers to foster this passion would be a vital step to begin to address ACC.

An additional component that has been examined in literature exploring student empowerment is the development of a critical perspective in students through the incorporation of social issues. Upadhyay et al. (2020) focused on utilizing a sociopolitical consciousness (SPC) framework to examine how students were able to be empowered to enact changes in their communities within the science classroom. SPC is implicitly embedded in addressing the political aspects of social, economic, and cultural issues that create tensions in one's community (Ladson-Billings, 2014; Seider et al., 2017). To explore

this issue, the authors examined the actions that were undertaken by students in a secondary science classroom. Through their analysis, the authors found that the students within the study viewed the central goal of science education to be to improve their ability to critically examine issues of social justice and discrimination in science contexts. Furthermore, to foster empowerment through SPC, it was noted that critical reflection leads to critical action through the support of their teachers. This provides support for the key role that teachers have in the classroom and warrants further exploration of how to support teachers to be facilitators of student empowerment.

Similarly, Phillips et al. (2019) utilized a sociocultural perspective to examine how individuals who participate in citizen science derive meaning in their work in order to remain motivated for their continued participation. In their initial review of literature of volunteer engagement and motivation, the authors noted that the literature suggests that initial motivation, positive experiences, and overall satisfaction with their activity lead to further engagement. The authors also noted that as described in Nov et al. (2014), intrinsic motivation is a sustaining factor for engagement whereas extrinsic motivations, such as social pressure or rewards, leads to initial engagement but that engagement wanes over time. To answer their research questions, the authors conducted interviews with citizen-science participants who participated in a wide range of projects. From their results, the authors provided a definition for engagement in citizen science as the "emotional, behavioral, cognitive, and social experiences that initiate and sustain lifelong learning and that are largely influenced by motivational factors" (Philips et al., 2019, p. 684). In this definition, the authors emphasized that the affective connection that the participants had was a key factor in sustaining engagement. This affective connection provides an opportunity to utilize social

justice issues with students in order to generate this connection to their affective domain. The reason for this is that social justice issues, as identified by students, allow for sustained engagement with the actions they are enacting. The authors culminated with noting that, along with the emotional connection that participants mentioned, the hands-on experience of the activities was also integral to their engagement.

Furthermore, Dimick (2012) examined how science classrooms can utilize a social justice framework to empower their students to take action in their communities. The framework that the author utilized had three central components: social empowerment, political empowerment, and academic empowerment. Social empowerment was defined as the integration of the social relationships that arise in the classroom between students and teachers as well as students with each other. Political empowerment was defined as a student taking a critical lens to structures and forces that maintain and establish power inequities within the sphere of political participation. Lastly, academic empowerment was defined as the requirement that students be prepared to succeed in traditional academic institutions as well as be prepared to critically examine how these institutions play a role in perpetuating systematic inequalities. From their results, the author found that social empowerment was supported when student voices were heard and valued. Political empowerment was supported when students were allowed to co-construct knowledge in the classroom along with their teachers. Academic empowerment was developed when students' lived experiences were integrated into the curricula and utilized as assets rather than impediments. The author recommended that, in order to develop and foster student empowerment in the science classroom, empowerment has to be viewed as a gradual process that considers how power is distributed in the classroom. The results from this study provided an example of how student

empowerment can be developed in the science classroom, however, a key area that was not considered is the role of the local community. The context of the study considered the local community as a setting for the study but did not explicitly consider the integration of the community in the classroom. As such, this leaves an area to further explore when considering student empowerment in the science classroom.

Lastly, a final key area to consider for student empowerment is how students conceptualize their roles as individuals who are capable of enacting change over time. To examine this, Levrini et al. (2020) analyzed essays, interviews, questionnaires, and video recordings of secondary students as they completed a module centered around climate change in order to develop future-scaffolding skills. These skills include scenario thinking, systems thinking, thinking beyond the realm of possibilities, action competence, and skills to manage uncertainty and complexity (Anderson, 2010; Rickards et al., 2014). Utilizing ACC as an issue for study because of its impact on the present and the future, the authors mentioned four areas that can be embedded with one another to support students in advancing their understanding of futures thinking. These areas were widening and approaching how students think about the future alongside the integration of structural and dynamic skills. Widening students thinking about the future involves focusing on expanding on what the future can include while approaching involves addressing that the future is more imminent than what students may perceive. To support this, structural skills such as content information about ACC alongside dynamic skills that allow students to understand how the future is ever changing support the development of widening and approaching thinking. Since ACC is an issue that can appear to be far in the future and not immediately threatening to most people, developing future-scaffolding skills are important to consider.

Student empowerment presents an opportunity in the science classroom to be a centerpiece of a framework for addressing complex issues such as ACC. As noted in Bertolonni (2021), through the use of student empowerment, teachers can impact the future of ACC mitigation and adaptation by developing future climate advocates. For this reason, more research on how teachers can foster student empowerment through the use of sociopolitical issues in the science classroom is needed.

In closing, student empowerment in the science classroom towards issues such as ACC can be achieved. Teachers can foster this empowerment and develop transformative students but have to be supported themselves to have the agency to address ACC in the classroom. Current literature has not fully explored the intersection between teacher agency and the issues that arise when attempting to teach complex issues such as ACC in the science classroom. The literature is further underdeveloped when considering how teachers can leverage ACC to empower students to be agents of change themselves. This study aims to help close these two gaps.

IV. Research Methodology and Context

The methods of investigation for this study were informed by integrating quantitative and qualitative methods, more specifically, the procedures outlined in Creswell and Clark (2017) and Wilson (2005). This integration consisted of utilizing an exploratory sequential design (Creswell & Clark, 2017). This design consists of an initial qualitative phase that is followed by a development phase that involves the transformation of the qualitative data into a tool that is quantitatively assessed (Creswell & Clark, 2017; see Figure 3). The strength of this design is that the newly constructed tool is grounded in the context of the qualitative data.

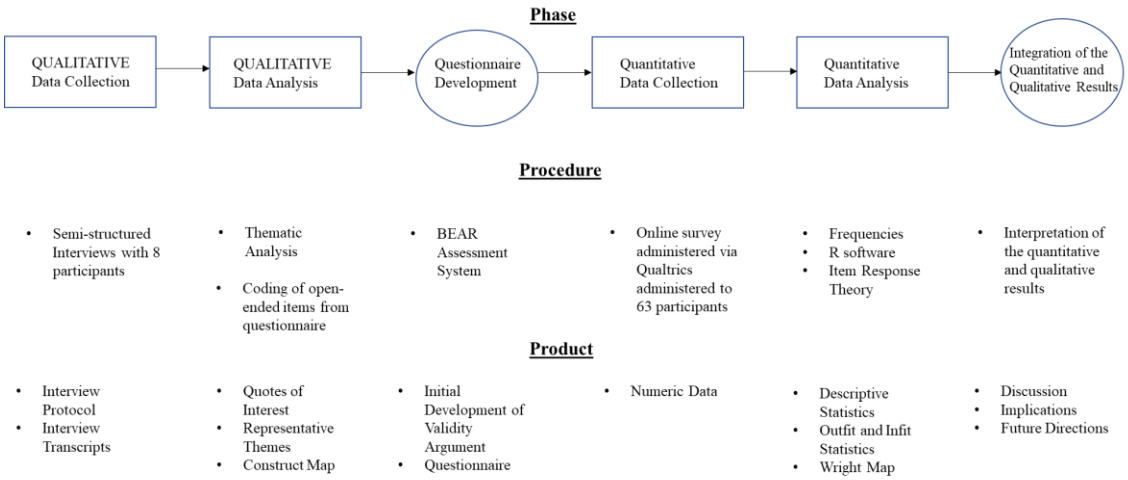
Due to the nature of the exploratory design and the context of this study, a dialectic paradigm (Greene & Hall, 2010) was utilized. This dialectic perspective was utilized due to the constructivist nature of the initial qualitative phase and the pragmatic perspective of the quantitative phase. A constructivist paradigm is necessary for the qualitative phase as it considers the world view of the participants (Denzin, 2012) while a pragmatic paradigm is considered for the quantitative phase as it consists of an initial pilot quantitative analysis. Through the use of an exploratory sequential design, the timing for the integration is sequential and conducted through the use of the qualitative results as the foundation of the quantitative tool. The rationale for implementing this design is due to its ability to provide findings that can be generalized through the use of the quantitative tool while being grounded in the perspective of the participants.

There are additional strengths in using this design as well. Through the use of this design, a questionnaire was developed that provides a new tool for teacher education programs to utilize that considers teacher agency in addressing climate change to inform their real-world practice (Creswell et al., 2004; Tashakkori & Teddlie, 2003a). Furthermore, this mixed

methods design has not been as commonly utilized in the emerging science education mixed methods literature (Schram, 2014), thus providing valuable insight into its application within science education.

Figure 3

Diagram of the Research Design



A. Study Context

This study was conducted over the 2020-2021 and 2021-2022 academic years. The context for this study was a large public university located in central California. The quantitative portion of the study was situated within a post-baccalaureate degree Teacher Education Program (TEP) located within the university. The structure of the TEP allowed the preservice teacher participants (herein referred to as "Preservice teachers") enrolled in the program to obtain one of three credentials during a span of a year. These credentials included a Multiple Subject Teaching (MST), Single Subject Teaching (SST), or an Education Specialist (ESC) credential. The preservice teachers also had an option to obtain a Masters of Education in Teaching Degree (M.Ed.) during their time within the program. The preservice teachers s within the program were separated by cohorts according to which credential they

were attempting to obtain. Within these cohorts, the preservice teachers were enrolled in the same coursework and worked collaboratively in a vast majority of their classes. The program typically admits roughly 100 students every year. The course work for each cohort varies but follows the same structure. The structure is ordered throughout the calendar year with courses in the summer providing a foundational curriculum the introduce candidates to research and theories of teaching. In the fall, candidates are prepared to begin designing learning experiences for diverse learners, with single subject preservice teachers beginning their content specific methods courses. In the winter and spring, all of the candidates are placed into their teaching practicums, with multiple subject teachers beginning their method courses which include science. Education specialists do not receive methods courses for science.

B. Participants

The participants for the study included participants both for the qualitative and quantitative phases. Within the initial qualitative phase, there were eight participants. (See Table 1 for a description of the participants from the qualitative phase.) These participants were selected for their different expertise pertaining to climate change education, climate change communication, climate activism, and/or behavioral actions related to the climate, among other areas. The participants were either associated with the university that the TEP under investigation was located in or professional educators located on the east coast of the United States. The experts' different expertise allowed for a collection of different themes that, in conjunction with the conceptual framework, resulted in a construct that undergirded the questions within the questionnaire.

Table 1

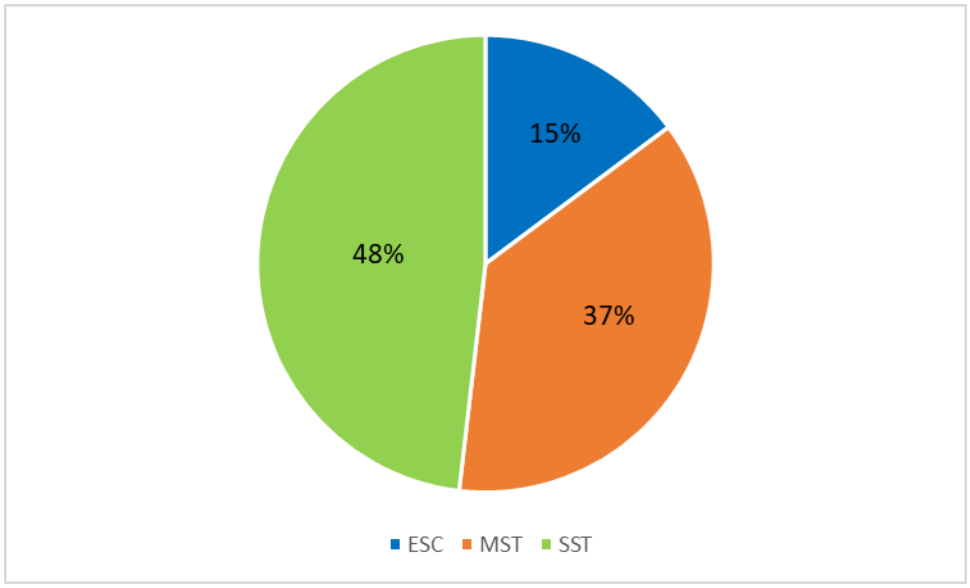
Participants and Their Expertise from the Initial Qualitative Phase

Participant Pseudonyms	Expertise	Profession
Dominic	Climate Change Policy & Behavior	University Professor
Susie	Environmental Policy & Politics	University Professor
Michael	Climate Change Politics	University Professor
Angie	Climate Activism	Middle School Teacher
Sabrina	Climate Justice	University Professor
Kelly	Teacher Education	Teacher Educator
Daisy	Community Outreach & Teacher Education	Outreach Coordinator
Erica	K-12 Teaching	Middle School Teacher

The participants for the quantitative phase consisted of preservice teachers within the TEP. All 81 preservice teachers within the program were asked to complete the questionnaire. The 63 who consented were then administered the questionnaire. The entire population of preservice teachers were asked to complete the questionnaire, not only the secondary science preservice teachers, as the issue of climate change education is one that has the potential to be integrated into all classrooms. As such, obtaining the perspectives of preservice teachers that are going to be leaders in different classrooms is necessary in order to understand how to best support them. See Figure 4 for a visualization of the number of preservice teachers per credential option for the 2021-2022 academic year and Figure 5 for a visualization of the preservice teachers who completed the survey.

Figure 4

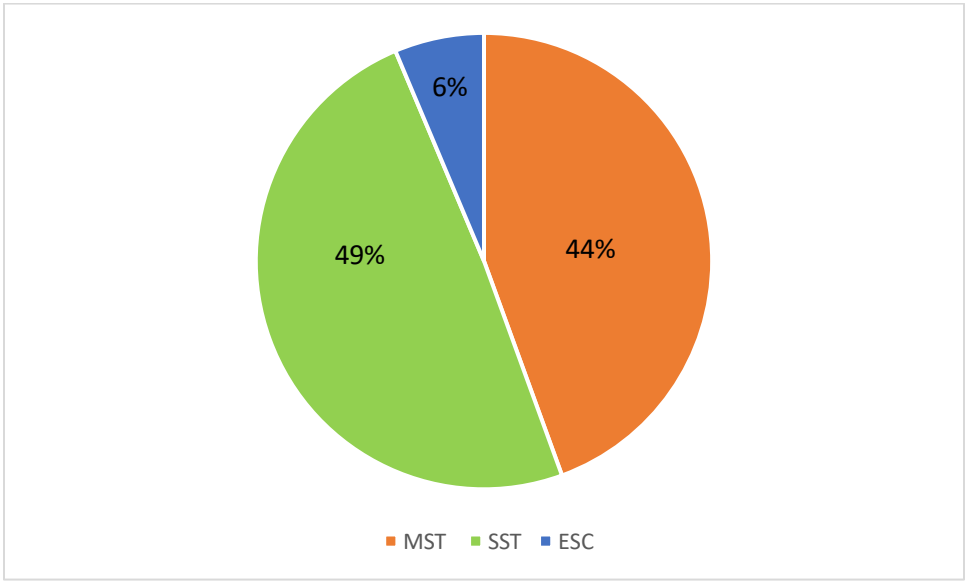
Preservice Teachers TEP Enrollment by Credential for the 2021-2022 Academic Year



Note. Total enrollment for the TEP in the 2021-2022 year was 81 preservice teachers.

Figure 5

Preservice Teacher Demographics by Participation in the Questionnaire



Note. Total participation in the questionnaire was 63 preservice teachers.

C. Data Collection

Data for the qualitative phase were collected through the use of a blended interview approach that combined a standard open-ended interview with a conversational interview (Patton, 2002). This approach was chosen due to the flexibility of having an interview protocol while also providing the freedom to deviate from the guide if an unforeseen topic of interest arose during the interview. The interview protocol implemented for the qualitative phase (see Appendix A) followed the recommendations set out in Brenner (2006) by being broken into four major segments. The first section of the protocol consisted of descriptive questions in order to have the participants become comfortable in the initial phase of the interview and to begin to establish rapport (Werner & Schoepfle, 1987; Yin, 2011). This initial section gauged the participants' general interest in climate change by asking about their earliest experiences with climate change education, their personal motivation for being interested in climate change, and the intrinsic factors they believed can encourage others to act against climate change. Following the initial section, the subsequent three sections were centered around the role of education, climate communication, and a wrap-up, respectively. These subsequent sections of the protocol contained core questions that provided the focus for the development of the subsequent quantitative phase. These subsequent sections of the protocol consisted of structural and contrast questions (Patton, 2002). Each section of the protocol was designed with the purpose of asking the participants about concepts that have been discussed in climate change education literature and have been identified as critical to consider for potential integration into classrooms (Feinstein & Kirchgasler, 2014; Kunkle & Monroe, 2019; Rousell & Cutter-Mackenzie-Knowles, 2020). This structure resulted in the interview protocol consisting of 14 questions.

Each interview was conducted in-person or over Zoom. The interviews took 45 minutes to 1 hour to complete, were audio recorded, and were then transcribed to allow for analysis. The transcription was conducted through a transcription software offered on the online platform of Zoom and the transcripts were checked by the researcher for accuracy.

Collection for the quantitative phase consisted of administering a newly developed questionnaire based on findings from the interviews via Qualtrics (see Appendix B). The questionnaire was administered during the beginning of the winter quarter of the 2021-2022 academic year across the months of January and March. The ESC candidates were administered the questionnaire in late January, the SST candidates in late February, and the MST candidates in early March. The duration of the questionnaire was 15-20 minutes and a total of 63 completed questionaries were collected. The questionnaire consisted of 24 questions that included a collection of 15 five-point Likert style items, five open-ended responses, and four demographic questions. Each section of the questionnaire was centered around a specific theme that was identified in the qualitative analysis. This resulted in the questionnaire having three major sections that asked preservice teachers about (1) their general attitudes and familiarity towards climate change, (2) their experiences with climate change curricula in their TEP, and (3) resources that their TEPs provided and additional resources preservice teachers believed would be beneficial to have from their TEPs that would allow them to address climate change in their future classroom.

D. Data Analysis

1. Qualitative analysis for expert interviews and questionnaire

For the qualitive analysis, thematic analysis (Braun & Clarke, 2006) was utilized for the detection of themes from the expert interview data in order to generate the core ideas for

climate change education. Thematic analysis is a method that allows researchers to identify what is recursive in the mannerisms that are embedded in the data, which themselves are derived from the participants. In this way, the themes or categories that are identified from the data are those that are derived from the meaning being given by the participants. In this study, an inductive approach was utilized as the themes that were of interest were those that were rooted in the data (Corbin & Strauss, 2007; Maxwell, 2013).

Using this approach, organizational themes were first formed from the qualitative interview data. From the organizational themes, descriptive examples, in the form of participant quotes, were identified that assisted in reinforcing what the themes conveyed. This process was guided by coding schemes (Appendix C & D) that were derived from the conceptual frameworks of this study. The first framework, teaching for transformative individuals (TTI), was constructed from the integration of civic science education (CSE; Rudolph & Horibe, 2016; Levy et al., 2021), justice-centered science pedagogy (JSCP; Morales-Doyle, 2017), youth participatory science (YPS; Morales-Doyle & Frausto, 2019), and culturally empowering pedagogy. The second framework considered professional teacher agency (PTA) as conceptualized by Priestley et al. (2016). Utilizing these coding schemes, I developed themes that were derived from the codes themselves. These themes were a reflection of the codes by providing an encapsulating group for the codes and their derivatives.

Furthermore, in this analysis, the coding schemes were utilized to qualitatively code responses from the questionnaire in order to examine the responses for alignment with the frameworks. For this analysis, the unit of interest were the responses provided by the preservice teachers. As such, the responses themselves could range from a singular word to

multiple sentences. The results of this analysis allowed for an examination of preservice teachers' alignment with the TTI and PTA framework. The TTI framework was utilized for a tier 1 analysis and then the same responses were analyzed for a tier 2 analysis utilizing the PTA framework. Tier 1 coding focused on analyzing the selected responses for codes centered around social transformation and tier 2 coding focused on detecting instances of PTA. Tables 2 and 3 present examples and definitions of the codes.

Table 2

Examples of Tier 1 Coding

Code	Example	Definition
Youth as transformative individuals	"Supporting students with resources on how to change their habits that impact climate change and how to implement those better in the classroom"	Participant mentioning their students being or supporting their students to be producers of knowledge, culture, and agents of change. These changes could be exemplified through support in changing or influencing student actions.
Culture as a tenet of teaching	"More indigenous ties to the environment and connecting students with the land they live on"	Participant recognizes culture being an integral part of teaching.
Recognizing social context in teaching	"How to/practice with integrating climate change education into subjects outside of science, like having discussions in language arts, learning about climate change	Participant recognizes that social context plays an integral role in teaching and education whether that be student context or context to issues being taught in the classroom.

	policy in history etc."	

Table 3

Examples of Tier 2 Coding

Code	Example	Definition
Deficit perspective with agency	"I think it's up to governments and large corporations to change and that there isn't sufficient individual action to combat climate change"	Participant mentions that they do not believe they have agency within their environment.
Experience	"When I have my own classroom, I hope to connect each of the units I teach to climate change issues, or the effects humans have on our local environments, however, right now, I am not ready to do that. I hope to take at least 2 field trips with students to build their connection with their environment, but right now I'm not prepared to do that"	Participant mentions experience as a factor that influences their agency.
Pressure to conform	"Trying to teach. lesson plans, go to classes, and grade is a lot. My mental bandwidth is running	Participant mentions feeling a pressure to conform to traditional classroom practices either through their administrators, fellow

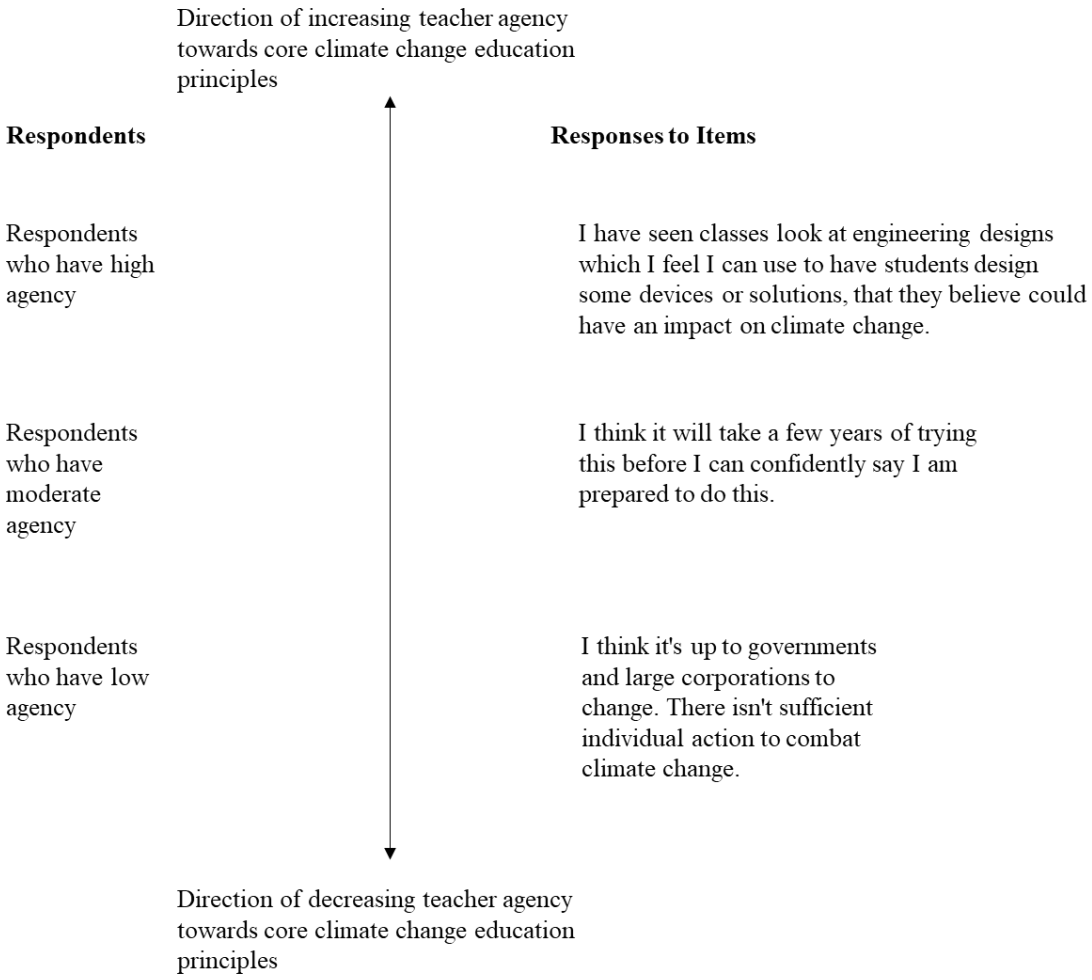
	low and can't really attempt anything new right now"	teachers, or traditional responsibilities.

2. Questionnaire Development

Overview. The development of the questionnaire followed the process outlined in Wilson (2005); this process is the Berkeley Evaluation and Assessment Research (BEAR) center assessment system. This system consists of defining a construct, an item design process, an outcome space, and a measurement model. To begin, the construct of interest that was examined by the questionnaire was teacher agency towards climate change education principles (TACC). More specifically, this construct, as represented by the construct map (Figure 6), defined a continuum where an individual can be located on the developing end of the continuum towards the direction of decreasing teacher agency or towards the increasing end of the continuum. This construct was a representation of preservice teacher's agency toward enacting the core ideas of climate change education identified in this study. As such, this allows the construct to be an iterative reflection of the TTI and PTA framework. The initial construct map was centered around the respondents and with the incorporation of respondent answers, the map was further refined to give clearer definitions of what individuals on the continuum could be classified as.

Figure 6

Construct Map for the TACC Construct



Development Process. To design the items for the questionnaire, I used the definition of the construct in conjunction with the results from the qualitative phase. The guidelines set out in Dillman et al. (2014) were utilized as well. The guidelines included choosing the appropriate question format or mix of formats, assuring that the questions apply to the respondents, the length and choice of words within the questions, and the ordering of the questions, among others. The outcome space for the questionnaire followed the account set out in Masters and Wilson (1997) by consisting of well-defined, research-based, context-

specific, and finite and exhaustive categories. Additionally, the process first described in Marton (1981) of utilizing phenomenography to develop the categories was applied as well. Using these applications to the outcome space, categories were developed that corresponded to scores. In this way, categories that corresponded to answers that provided increasing specificity were equated to increasing scores (Table 4). Lastly, the measurement model that was applied to the questionnaire was the RS model that was mentioned previously. Utilizing this process, 14 Likert questions were developed alongside 5 open ended questions.

Table 4

Outcome Space for Close-Ended Responses

Response Options	Score
Strongly Agree/Extensive	5
Agree/Sufficient	4
Neutral/A little	3
Disagree/Very little	2
Strongly Disagree/None at all	1

Validity Argument for Questionnaire. Validity has been noted as being the key aspect of a measurement tool (Sireci, 2009). There are different conceptualizations of what validity is, but for the purposes of this study, the traditional view was followed. This view posits that validity should be centered around the interpretations of the assessment and their subsequent uses. More specifically, the argument-based approach as outlined by Kane (1992) and AERA et al. (2014) was followed. To begin, the stated purpose of the questionnaire was to collect data on how much agency preservice teachers believed they had to implement climate change education principles. From the results of the questionnaire, strategies and supports were recommended to be developed that had no impact on the current standing of the preservice teachers. For evidence based on assessment content, an expert panel was

consulted when forming the questionnaire through a qualitative process as well as an additional review of the questionnaire by experts in science education and measurement. For evidence based on response processes, the analysis of the open-ended questions provided insights into the meaning the participants derived from the questions. For evidence based on relations to other variables, no preliminary analysis was conducted as there are not many similar measures as to the one described here. However, as more measures are developed that examine similar constructs, this strand of evidence can be later refined. For evidence based on the consequences of assessment, there were no known consequences for participating in the questionnaire as the data collected were anonymous and there were no decisions made as a result from the questionnaire that would impact the participants' standing in their programs. As with all validity arguments, the current one presented is constantly being refined and updated as more information is collected. However, for the purposes of this study, the evidence presented was deemed sufficient as the core of the validity argument for this iteration of the study was centered on the feedback received from the expert panel.

Quantitative Analysis. For the analysis of the questionnaire, an initial data transformation was conducted in the form of a quantification of the Likert scale items as follows: Strongly agree = 5, Agree = 4, Neutral = 3, Disagree = 2, Strongly disagree = 1 (Sandelowski, 2009*).* This method of data transformation has been noted to be one of the ideal techniques for mixed methods integration (Creswell & Clark, 2017), however, it is recognized that by undergoing this transformation the data themselves are not obtaining any quantitative properties (Michell, 1990, 1997, 2013). Thus, for the purposes of this study, the application of measurement utilizing quantification was to obtain high quality information about the construct of interest (Mari et al., 2017). Following the transformation of the data,

an initial descriptive analysis was conducted to gauge how the responses were initially represented.

Additionally, item response theory (IRT) was utilized as well in the analysis of the quantitative data. From IRT, a derivative of the Rasch model was implemented. The Rasch model itself represents a method that can help calibrate and construct measurement tools (Andrich, 1988; Wilson, 2005; Wright, 1984) by being able to predict the probability of endorsing an item as a function of both person ability and item locations, that are commonly depicted as Θs and δs respectively (De Ayala, 2009). By being able to predict endorsement, items can be altered and refined by using participant responses to examine the characteristics of the items. The Rasch model itself can be expanded through the addition of other parameters to account for the structure of the items. As this present study utilized Likert scale items (Likert, 1932), an extension of the Rasch model was applied. More specifically, the Rating Scale Model (RS) was utilized (Anderson, 1977; Andrich, 1978a, 1978b; Masters, 1982). This model was chosen as it has been identified as appropriate for modeling Likert scale data (Ayala, 2009). The RS model utilizes the parameter (τ_h) tau that represents a threshold that is on the continuum of the construct and is what separates response options. Using these parameters, the RS model predicts the probability for a person with location Θ passing a number of thresholds (x_j) on an item located at δ with a threshold (τ). By implementing this model, each participant will receive a score, which is the unweighted sums across items of the number of thresholds passed, in order to determine a person's location on the continuum of the construct. The results from this section of analysis allowed the development of insights that were a reflection of preservice agency towards the core ideas

that were generated from the expert interviews. The descriptive statistics and WrightMap from this analysis allowed for these insights.

The program for this analysis utilized R (version 4.0.5; R Core Team, 2021), an open-sourced software that is commonly used for statistical analysis. The packages in the analysis are TAM which implements Rasch modeling to fit a specified model to the data presented to the package (Robitzsch et al., 2018) as well as WrightMap (Torres & Freund, 2014) and birtr (Seock-Ho, 2017). Estimations of person ability (Θs), item difficulties (δs) were derived from the analysis. From the analysis, a Wright map was also constructed along with corresponding Item Characteristic Curves (ICCs; Lord, 1952). When examining model fit for the Rasch model, a combination of item fit statistics as well as a review of the ICCs and person estimates can be used in unison to determine whether the data fit the model. As the RS model is an extension of the Rasch model, the same criteria were used in this present analysis.

3. Integration

The integration of this analysis stemmed from the development of each of the different research questions. RQ1 was based on the initial qualitative phase that consisted of expert interviews that allowed for the construction of the quantitative questionnaire. From this questionnaire, RQ2 and RQ3 were able to be examined. This integration of RQ1 into RQ2 and RQ3 provided the foundation for the comparison that is needed for a mixed methods approach.

V. Interviews with Science Education and Climate Change Experts

This finding set focuses on addressing the first research question of this study: (1) What ideas core to climate change education were identified in the initial qualitative phase? To begin, I address the first research question by examining the themes that were derived from the initial qualitative phase that consisted of expert interviews.

From the interviews, strategies identified as core to climate change education were organized into three categories: the classroom, the student, and the teacher. The experts were eight individuals whose expertise consisted of climate change policy and behavior, climate activism, climate justice, teacher education, community outreach, and teaching within a K-12 setting.

A. Strategies for Developing the Classroom

The ideas experts identified related to the classroom did not exclusively focus on the content of climate change. Rather, the themes were as follows: building community, climate communication, emphasis on solutions, interdisciplinary approaches, and localization. Below, I discuss each of these strategies in turn.

One theme, that of building community, primarily focused on fostering a sense of belonging within the classroom. This sense of belonging within a community allows students to recognize that climate action is something that is achievable by themselves and their peers. By seeing climate action being enacted within their classroom community, students can experience that attending to ACC can be accomplished through ordinary actions and can be a rewarding experience. This was reflected upon by Sabrina:

> *I think we have to convey [that] climate action is something ordinary people do and not make it something someone far removed and heroic does, that it's the ordinary*

> *people that look just like us do, and that it is fun. And it fosters community.… It provides meaning and purpose. And so, I think that we have to, you know, convey it as ordinary but also exciting, fun, and something [doable].*

Focusing on this community within the classroom provides students a connection with other individuals and additionally allows for a space where climate actions can not only be planned and observed, but also reinforced. Allowing students to observe and be immersed in seeing their peers enacting actions against climate change serves as a way to establish new social norms within the classroom community. This was highlighted by Susie: *"It could also be kind of community reason right or what social psychologists called social norms reasons. Everybody else is doing something. So, I should do something."* In this way, the social norms serve to encourage behaviors that result in climate action in some manner. These behaviors could vary, but they would be reinforced through the interactions with peers within the classroom community.

Furthermore, developing and supporting a community within the science classroom provides an anchor from which to initiate climate actions. To elaborate, starting at the classroom level would provide a more intimate area which could then be extended to the school level, followed by the local community level. Each successive level provides an opportunity to extend climate action at a larger scale that would serve as reinforcement that impact and change is possible at almost any level. Indeed, developing a community in the classroom provides an introduction to how being a member of a local community can be extended into being a global community member. This is important to consider as ACC can be perceived as an issue that is distant and does not immediately impact a student's local

environment. Sabrina elaborated on this point by connecting action to perception of one's reality:

> *Whereas inside I think a lot of people don't feel like it's kind of like a survival guilt like, "Oh, well, I'm doing okay because climate change is not really hurting me. I'm not drowning, so you know, I should not get involved. That's not my agenda, because I'm doing okay." So, we have to communicate how, like, none of us are doing okay.*

A second way noted to be a key idea to consider when enacting climate change education was climate communication. This communication spans the ways in which the impacts of ACC are spoken about to what should be emphasized as effective approaches to combat ACC. For example, Daisy highlighted the need to focus on communicating solutions that can help mitigate and potentially assist in adapting to ACC:

> *So I think number one, my mind's jumps to like how important it is to emphasize that there is a solution. There are possible solutions. And this is what we need to do to get to those solutions. So, kids might be learning information about [the] problem, but they also have the opportunity to be part of that solution, like right in the lesson*.

This emphasis on solutions, a third classroom focus, provides an avenue to not only address issues such as climate anxiety and the generational climate divide, but a bridge to develop an underutilized area of STEM education. Climate anxiety is an issue that can emerge when addressing ACC in the classroom as ACC is a global issue that has had and will continue to have global impacts. As a result, students can feel overwhelmed by ACC and believe that they cannot have an impact against the issue since it is so large. Emphasizing solutions can allow students to develop and focus on a tangible plan to enact that provides them a sense of hope. These solutions can integrate issues that intersect with ACC, such as

considering how ACC can exacerbate environmental racism. Michael mentioned this when describing how to anchor ACC through a focus on solutions:

> *Thinking about issues like adaptation, thinking about issues like environmental justice, you know, I think that there's a lot of ways in which this can be made a much more concrete issue, rather than an issue that started very abstract.*

Connecting back to the second point about communication, solutions provide a potential bridge when communicating about ACC across the generational divide. ACC is an issue that can be divisive since it is deeply intertwined in politics. As such, it can cause communication to falter when addressing the issue not only in the classroom but when communicating with parents or members of the community. By using solutions as the focus of communication, the interests or concerns that different people may have about ACC can be met through these solutions to emphasize that everyone has a vested interest in combating ACC. Michael expanded on this by stating:

> *So that there's sort of like a social understanding of climate change as sort of a problem that we can do something about, and often that's not about persuading someone, but about making them feel comfortable communicating and talking about what they already believe and accept.*

Most solutions that are presented within the science classroom traditionally are centered upon biological systems that can be influenced through human intervention. However, one area that has been historically underutilized in science classrooms is engineering. One reason for this is that ACC is considered an issue that primarily affects biological and chemical systems. This may result in solutions that are centered on anthropogenic actions that are based on human action alone. As a result, common strategies against ACC typically include

recycling or turning off lights when leaving a space. A focus on solutions presents an opportunity, as mentioned by Susie, to focus on the development of new technologies using an engineering perspective:

> *You know, I think the technology of technology, the technology of climate mitigation is really interesting, or even climate adaptation is really interesting. Right, you could imagine like in an engineering classroom that thinking about carbon mitigation would be super fascinating.*

Two additional key areas that were mentioned as ideas to bring into the science classroom when covering climate change education were one, the role of an interdisciplinary perspective and two, the importance of localizing ACC. An interdisciplinary perspective involves integrating the outside context of ACC with topics that are traditionally covered within the science classroom. This includes areas such as politics, economics, and issues of social justice. The reason for this integration is to inform students about the sociopolitical aspect of ACC that extends outside of the laboratory. For example, understanding how the science of ACC is impacted by or informs national policy is an area that is underutilized in the science classroom. Understanding how policy shapes ACC can also give students a glimpse of how enacting change within the political system can have systematic impacts at the national level to reduce greenhouse gasses. Dominic elaborated on this further by stating:

> *At the institutional level is where you can affect the greatest change because institutions, whether it's government or industry or international associations, they necessarily impact more behavior.… Governments and government policy is going to really determine carbon levels at a large level by forcing industry and individuals to change their behaviors.*

Furthermore, by adopting an interdisciplinary perspective, collaboration among teachers can present an opportunity to innovate new pedagogical strategies for climate change education. Kelly described her process in collaborating with educators from different disciplines:

> *Climate change is very complex. And the only way we can really make people understand it is interesting is through an interdisciplinary approach and really seeing from, from kindergarten to 12th grade, you know, just interweave it.…So now I'm starting to work with the social science and history instructors at the teacher education program, and we want to move together and co-teach a little bit more.*

In addition to an interdisciplinary approach to climate change education, presenting ACC as local was noted to be key as well. This could be either through emphasizing local actions, such as developing community gardens, highlighting change through local government, or focusing on local problems. Focusing on the local community utilizes a connection that students have with their local space as it is an area that they explore and reside in on a daily basis. Additionally, if ACC is localized, the changes that are enacted at a state or federal level to combat ACC can be first developed at a local level to provide an experience of how change can be made. This connects back to the first strategy identified above, the importance of creating a classroom community. Kelly provided an example of how sustainability can be utilized within a local context:

> *Our students are really interested in the clothing industry, and it is a catastrophe in regard to climate change. So, you know, how can we work with that. Maybe we can consider Los Angeles in the local fashion industry and say, okay, so this is what we know about the impacts of the fashion industry on nature and on climate. And this is*

what we want you to change. And we will not buy any clothes from you until you change that.

In sum, experts identified five key ideas to integrate into the science classroom when addressing ACC. In addition to the classroom, ideas for supporting students and teachers were identified as well.

B. Strategies for Developing for the Student

In addition to supporting climate change education in the classroom, two key ideas were identified for developing the student, who is going to be immersed in the curriculum of ACC. These ideas revolved around one, establishing an early connection to nature and two, empowering students as agents of change through civic knowledge. In conjunction, these ideas provide a connection to the curriculum that places students in a position to see themselves as able to leverage knowledge and practices needed to influence their community against ACC.

An early connection to nature was highlighted as important to establish – to develop a sense of attachment to nature and a desire to protect it. This connection to nature could then be further honed to help students connect to their local community. As a result, different approaches can be utilized that can emphasize the importance of exploring and being in nature. By utilizing the affective domain of students, a deeper connection can be established that can persist over a long period of time. For example, areas that could be developed within students to foster a connection to nature through the affective domain are compassion and empathy. These feelings could then be utilized as a bridge to give a personal connection to ACC by understanding how different people on the planet are impacted by ACC due to their social circumstances and contexts. This was explored by Daisy when speaking about her

passion for climate change education*, "First, obviously, it's like about learning and developing that connection with nature. That was a really important part of my personal connection to my interest in climate."* Kelly echoed these sentiments:

> *K all the way to 12, instead of trying to like expose students to it later on where they're like, "I have no connection to this because you're just telling me right now." We could foster a connection where they have it throughout their life. And it doesn't need to be necessarily about climate change but fostering our relationship with nature.*

Sabrina additionally described how a connection to nature can be fostered despite ACC being a topic that is historically addressed in later grades:

> *Climate change as a topic does come a little bit later, but like in the younger grades, you can start to cultivate a love for the environment, a love for each other.… Then you can start to talk about the, the disruptions and the challenges to the thing that you've, you've learned to love.*

Empowering students as agents of change additionally provides an opportunity to allow students to move the curriculum outside of the science classroom and into their reality. This can be achieved through highlighting the actions and stories that individuals have taken in their community and by exploring how students can leverage the political system to achieve change in their local community as related to ACC. Knowledge of the political system can allow students to see ACC as a complex socio-political issue that is not isolated in the science classroom. For example, understanding the intersection of economics and how corporate influences generate a narrative to protect their financial interests at the expense of the climate can have students think about comfort versus sustainability. This extends to

having students consider what actions they can demand corporations enact in order to mitigate ACC. By giving students the tools to think about how the public interacts with the political system through the intersection of the science classroom and the government, students can hold power as informed individuals who can demand change within their institutions, whether that be in their workplace, school, or from their government. Susie elaborated on this point when speaking about the power of individuals to effect institutional change:

> *At the institutional level is where you can have the greatest change because institutions, whether it's government or industry or international associations, they necessarily impact more behavior.…So by participating in those institutions, individuals can shape the direction of those institutions.*

Dominic agreed with this notion of influencing government action through individual voices:

> *You can increase hope by empowering people through knowledge of the government, and how government works and how government can work better…. That the solutions to climate change are going to be a combination of individual action, government action, and industry making changes.*

To this point, experts presented ideas about developing the classroom and students in relation to climate change education as critical to consider. However, the individuals who are going to facilitate student understanding and enactment of these ideas are teachers, so experts viewed supporting and developing teachers in relation to climate change education as crucial to examine as well.

C. Strategies for Developing the Teacher

Within the classroom, the teacher determines how ACC related curriculum is enacted. As such, additional ideas were identified to provide support for teachers in order to enact climate change curriculum. Two key ideas were identified by the experts interviewed: providing a support system around the teacher at all levels of implementation and exploring the connections that teachers themselves have with ACC and nature.

The support system that a teacher would require to effectively implement ACC education involves all levels of their environment, experts explained. These levels are composed of the micro, meso, and macro systems that are in place around a teacher. The micro level consists of their classroom, the meso level consists of their administration, and the macro level consists of the district. Each of these levels presents unique opportunities and challenges but must be considered for teachers to feel supported in enacting climate change curriculum. For example, some of the challenges that teachers face include not having adequate support from their colleagues or administration in enacting curricula that is related to the environment or ACC, as noted by Daisy:

> *When I started teaching, I moved to my first teaching job [which] was down south and the culture down there was different than up north, you know, like people didn't talk about environmental issues.… [For teachers to teach about ACC] would require buy in from the district, you know, a district saying, "We support this."*

Additionally, a lack of resources to provide activities and strategies to address ACC in the classroom, whether they come from science education researchers or professional development directors, was identified as a related challenge that teachers face. Sabrina identified this need:

We need more resources for our teachers, and we need to stop asking our teachers to like come up with solutions to [teaching ACC] and putting the burden on them. We need to provide like more paid opportunities for teachers who want to teach about climate change.

Kelly added that professional development opportunities were needed as well:

Professional development is helping some develop or implement units in their classroom… that they can embed climate change in their normal teaching without, you know, doing too much different, because it's hard to change your teaching alone.

Equally important, considering the beliefs that teachers come into their classrooms with was considered by experts as key to examine as well. Teachers hold positions of power within their classrooms and the beliefs that they have about content can impact how certain topics are examined or if certain topics are addressed at all. This is vital to consider, especially in the context of ACC within the classroom, as noted by Angie*, "Teachers are in a position to change the world, they really are. They have such power to mold and influence the future through their students."* Dominic added to this by describing how teachers can appeal to the affective domain of their students by empowering them through knowledge:

[Teachers] can increase hope by empowering people through knowledge of the government, and how government works and how government can work better. And the roles that citizens play in government and the choices that government makes and how that can be influenced for both positive and negative forces so that they understand the government and the impact that government has.

D. Summary of RQ1 Findings

To summarize, the ideas presented from initial interviews with a range of experts considered three components – the classroom, the student, and the teacher – as integral to effective instruction about ACC. These ideas should be integrated with the content that is presented in the science classroom when covering ACC, they emphasized. Considering these ideas, such as presenting ACC as interdisciplinary or empowering students to be agents of change, could provide new approaches to ACC education that help students to develop a deeper connection with ACC and an added motivation to enact action against it.

VI. Questionnaire Analysis and Integration

This finding set focuses on answering the second and third research questions of this study: (2) How did PSTs perceive their agency in addressing ACC in their future classrooms? (3) What content and supports in enacting climate change education did PSTs identify? In particular, how did these areas compare to the core ideas that experts identified and to the framework of transformative teaching of individuals?

To address the second research question, I report descriptive statistics and an IRT analysis that were generated from the questionnaire. To address the third research question, I report on a qualitative analysis that examined the content and supports that PSTs identified as well as how PSTs' open-ended responses aligned with the teaching for transformative individuals (TTI) framework.

A. RQ2: Preservice Teacher Beliefs, Attitudes, and Agency Towards ACC

1. Overview of PSTs' ACC Beliefs and Attitudes

Most PSTs responded positively to questions that probed their attitudes and beliefs towards ACC (Table 5). To elaborate, 68% of PSTs reported that they had both a sufficient connection to nature and sufficient knowledge of ACC. Indeed, 86% of PSTs agreed that forming a connection with nature is important for their students as well. In addition, 91% of PSTs reported that they had a moral duty to implement actions to mitigate ACC as well as 80% agreeing that they enacted or encouraged others to implement actions to mitigate ACC. When considering the impact of individual and collective actions, 73% agreed that individuals can have a positive impact on ACC and 98% reported that corporations and nations had a vital role in mitigating ACC. These beliefs and attitudes are foundational

components to teach about climate change. However, only 28% of PSTs indicated that they had sufficient knowledge about climate change education itself.

Table 5

List of Questions for Preservice Teacher Beliefs, Attitudes, and Agency

Question Number	Question
Q1	How connected did you feel to nature through your experiences growing up?
Q2	How much do you know about climate change in general?
Q3	In general, I think I have a moral duty to enact actions to mitigate climate change.
Q4	In general, I enact actions or encourage others to enact actions to mitigate change.
Q5	In general, I think that individual actions can have a positive impact on mitigating climate change.
Q6	In general, I think that corporations and nations have a vital role in mitigating climate change.
Q7	At this time, I think that forming a connection with nature is important for my students.
Q8	At this time, I think I can empower and support my students in taking action against climate change.
Q9	At this time, how much do you know about climate change education in general?
Q10	Upon completing my program, I plan to integrate climate change related curriculum into my content.
Q11	Upon completing my program, I plan to integrate social issues such as poverty and inequality of resources into my content related to climate change.
Q12	Upon completing my program, I think I will be able to effectively collaborate with other content instructors to create interdisciplinary material rerated to climate change.
Q13	Upon completing my program, I think I will be able to foster a sense of community in my classroom centered around empowerment and student action against climate change
Q14	Upon completing my program, I think I will be able to implement activities or projects that are related to climate change that empower my students to be activists and to create change in their communities

These results indicate that, overall, the PSTs who were administered the questionnaire had a positive attitude towards mitigating ACC. This mitigation was both through their own direct action and through encouraging others to do so. This positive attitude toward

mitigation, in part, might be influenced by their knowledge of ACC and connection to nature through their own lived experiences. Additionally, the PSTs agreed that forming a connection with nature is important for their students and, by extension, that their students as individuals can make an impact in mitigating ACC. The disconnect of note was the depth of knowledge that PSTs reported about climate change education itself. Close to three quarters of PSTs who responded to the questionnaire indicated that they did not have sufficient knowledge about teaching ACC within their classroom.

2. Preservice Teacher Agency Towards Core Climate Change Ideas

Examination of specific items that investigated the agency that PSTs had to teach ACC also revealed that most of the PSTs surveyed believed they had agency to enact the core ideas that were identified in the expert interviews – even though they had insufficient knowledge about how to teach ACC within their classrooms. More specifically, 81% of PSTs reported that they could empower and support their students in taking action against climate change. This is supported through 79% of PSTs agreeing that they planned to integrate ACC related curriculum into their content. Exploring the connection between social issues and ACC, 88% of PSTs reported that they planned to integrate topics such as poverty and inequality into their ACC related content. Connecting further to the core ideas that were identified from the expert interviews were items from the questionnaire asking about PST agency toward developing interdisciplinary materials related to ACC, fostering a sense of community in their classroom centered around student empowerment and action, and developing and enacting activities that empower their students to be transformative individuals. Sixty-two percent of PSTs indicated they would be able to collaborate with other content instructors to create interdisciplinary material related to ACC. When considering fostering a classroom

community centered around student empowerment and action, 73% of PSTs reported that they agreed they would be able to accomplish this. Lastly, 69% agreed that they would implement activities or projects that are related to ACC that empower their students to be transformative individuals that create change in their communities.

From these above items, then, PSTs indicated that they had the agency to enact the core ideas that were identified from the expert interviews. This is furthered supported by Table 6, where the most common response for most items under examination coincided with a value of agree or higher. However, there were areas that PSTs could use further support in developing, such as being able to collaborate with other instructors to create interdisciplinary material or being able to enact activities in their students' communities. These items and others that have a mean of less than 4 all represent areas in which PSTs could be further supported in.

The above patterns are also supported when considering the difficulties of items of the WrightMap from the IRT analysis (Figure 7). From the figure, most of the participants agreed that ACC is a priority and plan to enact climate change curricula. This is reflected by most of the PSTs being able to endorse the response options that are agree/sufficient or above as indicated by category 4 and 5. More specifically, when examining the person abilities that are on the left side of the figure, the vast majority of the blocks encapsulate the items that are at the 4 or 5 level. This indicates that a minority amount of the preservice teachers from this study do not believe they are agentic to enact the core ideas that were identified. Key exceptions were individuals who were at the top and bottom of the map, who represent the extreme ends of the spectrum. One key finding to note, as previously mentioned above, is that the most difficult item to endorse at a level of agree or higher was item 9 that asked

about climate change education knowledge. More specifically when examining the mean of item 9 in Table 6, it is noticeably lower than the other item means. This indicates that, although PSTs might be willing and eager to enact ACC related curricula, they did not feel as though they had the requisite ability and knowledge to do so. The item means of the other items also provide areas of interest for TEPs to consider. For example, the items that have a mean below 4 are representative of areas that preservice teacher candidates do not believe they can as strongly enact when compared to the items with means of 4 and above. This is a result of these target items being representative of more responses at the neutral or disagree level. As a result, more preservice teachers need further support within these items (Table 7).

Table 6

Descriptive Statistics for Likert Questions

	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14
N	50	50	49	48	49	49	49	49	49	49	49	49	49	49
Mode	4	4	5	4	4	5	5	4	3	4	5	4	4	4
Median	4	4	5	4	4	5	5	4	3	4	4.5	4	4	4
Mean	3.84	3.78	4.44	4.12	3.86	4.88	4.45	4.04	3.18	4.04	4.41	3.77	3.96	3.85
SD	.95	.68	.71	.76	.89	.39	.74	.86	.73	.67	.65	.83	.79	.73

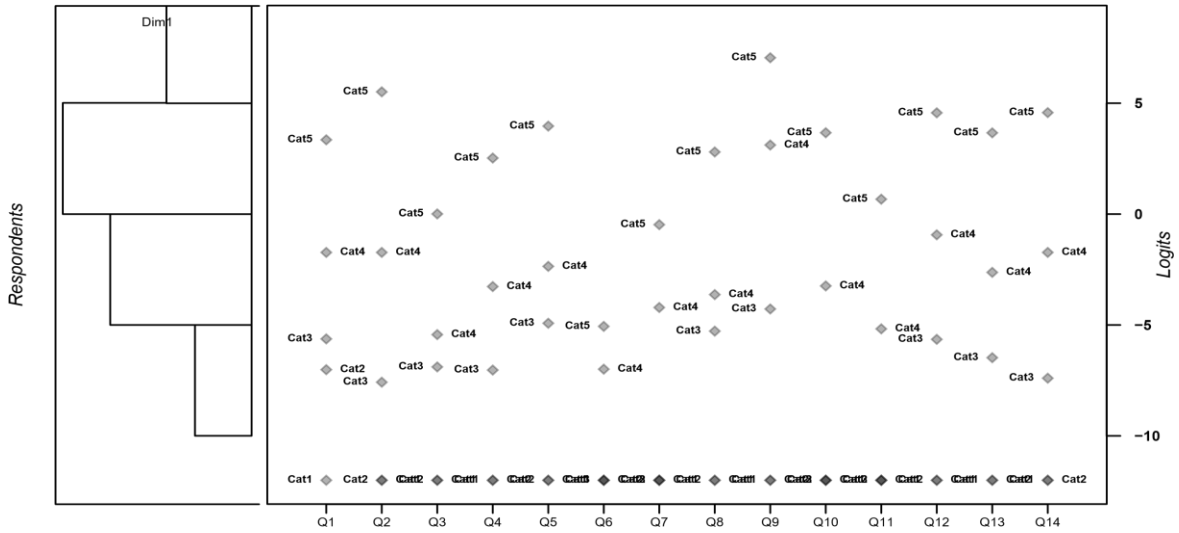
Table 7

Target Items for Preservice Teacher Development

Question Number	Question
Q1	How connected did you feel to nature through your experiences growing up?
Q2	How much do you know about climate change in general?
Q5	In general, I think that individual actions can have a positive impact on mitigating climate change.
Q9	At this time, how much do you know about climate change education in general?
Q12	Upon completing my program, I think I will be able to effectively collaborate with other content instructors to create interdisciplinary material rerated to climate change.
Q13	Upon completing my program, I think I will be able to foster a sense of community in my classroom centered around empowerment and student action against climate change
Q14	Upon completing my program, I think I will be able to implement activities or projects that are related to climate change that empower my students to be activists and to create change in their communities

Figure 7

Wright Map for Participants and Questionnaire



3. Preservice Teachers' Agentic Struggles to Enact ACC

To continue to explore PSTs' agency to enact ACC beyond the quantitative items from the questionnaire, an exploratory analysis was conducted on open-ended responses utilizing a coding framework that was centered around professional teacher agency (PTA). Items 8, 11, 12, 13, 14 contained an option to provide a response if a PST indicated that they disagreed they were able to enact what the question was asking. The number of responses to these open-ended questions was low; as is clear from the above analyses, most PSTs intended to implement ACC education in their future instruction. Still, from these small number of open-ended responses, areas of agency related to ACC that PSTs reported they struggled with can be identified.

Item 8 asked about the agency PSTs had in empowering their students to be agents of change against climate change. Three open-ended responses were recorded for this item. One response was coded as a deficit perspective to agency, another was coded as experience, and a third, as pressure to conform. For the deficit coded response, the PST stated that individuals do not have a role to play in mitigating ACC whereas for the experience coded response, that they were not currently prepared to empower students despite a desire to teach related topics. An SST science candidate described this as follows:

> *When I have my own classroom, I hope to connect each of the units I teach to climate change issues, or the effects humans have on our local environments, however, right now, I am not ready to do that. I hope to take at least 2 field trips with students to build their connection with their environment, but right now I'm not prepared to do that.*

Further, for considering a pressure to conform, a PST who was enrolled in the SST mathematics program described the need to balance primary responsibilities: *Trying to teach, lesson plans, go to classes, and grade is a lot. My mental bandwidth is running low and can't really attempt anything new right now*.

For item 11, when asked if PSTs planned to integrate social issues such as poverty and inequality of resources, one PST provided a response that was coded as a deficit perspective with agency. In their response, this EST candidate (Mild to Moderate) stated, "*I would love to put strongly agree but for special education teachers, we often just go off the content provided by the general education teachers*." Their response conveyed that they did not believe they had the agency to enact ACC related curricula as they built off of the content provided by general education teachers. A possible avenue to address this developing sense of agency would be through collaboration with the general education teacher. Through this strategy, this PST would be able to enact ACC related curricula by utilizing one of the core ideas identified earlier.

Item 12 was centered around the core idea of collaboration. From two responses that PSTs provided, they described an issue with experience as a confounding factor. For example, an EST candidate (Extensive) described a learning curve for collaboration:

> *I find that collaborating with general education and special education teachers is difficult due to the content they want to teach, and it could be doable but would be a learning curve for both parties to create an effective effort.*

This response communicated a need that can be addressed within TEPs.

Through the examination of fostering classroom community in item 13, two additional PST responses were collected. From these responses, the codes of experience and pressure to

conform were applied. In the case of the experience code, the MST candidate stated, "*I think it will take a few years of trying this before I can confidently say I am prepared to do this*." The pressure to conform code was applied to an SST science candidate who stated, "*I am almost afraid to as a first-year teacher because of parent backlash. I would want to be really informed and know why and how it works."* From these open-ended responses, these two PSTs communicated a need to be better supported in their preparation to be able to foster an ACC-focused classroom community and empowered in their ability as professionals to cover ACC content within their classrooms.

Lastly, for item 14, PSTs were asked about their agency to implement activities or projects that are ACC centered that place students as agents of change. A singular response was provided by an SST mathematics candidate, who wrote, "*I don't know if coming straight out of this program I will be able to immediately start incorporating climate change into my teaching, I will be thinking about it and trying though*." A code of experience was applied to this response because the candidate referred to coming out of the program with this perspective. This could potentially indicate a further need for TEPs to provide PSTs with experiences that would allow them to be more agentive in what they think they can enact.

From this analysis of qualitative responses, then, two key points of support were identified for areas that PSTs reported that they struggled with. These key points were a lack of experience in enacting the identified core ideas of climate change education and a pressure to conform to traditional classroom practices. As such, this presents points of emphasis for TEPs to consider in the future when empowering their PSTs to be agentive individuals who can address sociopolitical content such as ACC.

4. Summary of Beliefs, Attitudes, and Agency Findings

The analysis of data to answer RQ2 convey two key findings. The first is that PSTs viewed climate change education favorably and were agentic to enacting associated curriculum. The second is that PSTs reported a lack of clarity on what climate change education entails within the classroom. From these findings, different strategies can be enacted to provide PSTs with a deeper understanding of what climate change education is. For example, helping preservice teachers from all areas gain experience with ACC related curricula or providing examples of how collaboration with other content instructors can be achieved, could empower preservice teaches to be more agentic in enacting the core ideas from this study and fostering agency within their own students. The following section, which answers research question three, offers different insights into what preservice teachers report they require in order to enact ACC related content across different areas.

B. RQ3: Preservice Teacher Identified ACC Content and Supports

Within the survey administered to the preservice teachers, there were a number of open-ended questions that asked teachers about enacting ACC curricula, challenges that they may have had enacting the curricula, and resources they perceived they needed from their current program or future classrooms. Different key themes were identified around the content and supports preservice teachers stated they needed for the enactment of climate change education. I first describe the content PSTs discussed including in their future ACC instruction. Then, I discuss the resources and supports they identified as important for ACC instruction. These were subdivided as identified into three areas: from their teacher education coursework, their placements, and their future classrooms. Additionally, PSTs recommended supports for TEPs to consider for future PSTs.

1. ACC Content

PSTs indicated that they plan to enact ACC related content as shown by Table 8. This is conveyed by 79% of total PSTs agreeing that they planned to integrate ACC related curriculum into their content. Topics related to ACC that preservice teachers planned to teach, in order of most to least common, were the following: mitigative actions against ACC and how to enact them, solutions to ACC, the causes of ACC, and the consequences of ACC. The order of the responses of Table 8 were arranged in a way to highlight the traditional direction of how ACC is taught within the classroom, from the causes to solutions. From the number of responses, it can be inferred that preservice teachers are recognizing that actions and solutions for ACC are critical to consider alongside if not more than the traditional topics of causes and consequences. Additionally, some PSTs marked other as the area they were going to integrate about ACC into their curriculum. For those who selected other, their responses included the following: the cultural practices that impact climate change, effects of climate change on local communities, general trends and graphs about climate change, capitalism, ways in which individuals can create positive impact, and the intersection of social justice with climate change. These responses indicate that PSTs did want to integrate ACC related curriculum into their future classrooms. Furthermore, the responses recorded also provide evidence that PSTs wanted to integrate issues that are centered around activism and social justice issues as indicated from the responses derived from the other category.

Table 8

Preservice Teacher Content Choices

The causes of climate change	The consequences of climate change	Mitigative actions against climate change and how to enact them	Solutions for climate change	Other

31	29	37	32	6

2. Needed Supports

From the questionnaire, preservice teachers identified and reported what supports they would need from their coursework, placements, and future classrooms.

Teacher Education Program Coursework. PSTs' responses (n=53) related to their teacher education program were categorized into two categories: resources provided by their TEP courses (n=27) and resources absent from their TEP courses (n=26). Resources mentioned included NGSS-aligned content (n=7), pedagogical strategies (n=10), digital media (n=7), and underrepresented curriculum resources (n=3).

Table 9

List of Questions for PSTs' Recommendations and Supports

Question Number	Question
Q15	What information, resources, or tools have you been provided with in your program regarding climate change education?
Q16	What information, resources, or tools would you recommend the program address for future cohorts regarding climate change education?
Q17	What information, resources, or tools have you seen implemented in your placements that you think you could use in integrating climate change topics into your future classroom?
Q18	What information, resources, or tools do you think you would need from your future school in order to implement climate change education in your classroom?
Q19	What is something that you think our study should consider for supporting preservice teachers in integrating climate change education in teacher education programs?
Q20	If I were to integrate climate change into my content, I would focus upon?
Q21	What is a question that you think should have been included in the survey?

When describing NGSS related supports, PSTs described units that were conveyed in their coursework. Some preservice teachers mentioned being exposed to climate change

related phenomena and being shown how to approach and teach these phenomena in their classrooms during teacher education coursework. This was mentioned by a PST enrolled in the MST program, "*In a class solely dedicated to science teaching practices, we've been exposed to climate change-related phenomena and shown different ways to approach and teach these in elementary classrooms*." These phenomena mainly centered around designing labs or lessons plans that had an ACC component, such as ocean acidification.

Other preservice teachers mentioned being given strategies for addressing ACC in the classroom that directly addressed climate communication. For example, a PST that was enrolled in the MST program mentioned that their TEP provided them with strategies to address ACC in the classroom, "*My TEP provided the tools to have conversations around climate change*." Additionally, another PST enrolled in the MST program described being provided with strategies to reduce climate anxiety, "*I received some advice on how to talk about [ACC] while reducing anxiety*."

Further, some preservice teachers stated they learned about digital content in the form of websites or online interactive modules for their students in their TEP courses. For example, an MST candidate mentioned, "*Once in our science course. We had websites to explore the concept*." Another candidate also added needing additional resources that could be utilized in future contexts, "*Probably a couple links to some websites that we could base our lesson plans on. Honestly nothing significant enough for me to be like 'yeah let me save this as a resource for my future students'."* Responses such as these communicated a need to provide digital resources that can be more than websites and that can be used in the present and future.

Less prevalent were resources that extended beyond the walls of the classroom. For example, a singular PST who was enrolled in the SST program in science reported resources that integrated cultural connections or outdoor experiences, "*I've received all forms of media, nature hikes, indigenous myths, and engineering*." This presents a disconnect with the ideas that were identified from the expert interviews which called for a connection to the community outside the classroom.

The resources that PSTs reported primarily came from the science methods courses that were specific to their respective program. However, there was a reported difference between the PSTs in the MST and SST programs. MST students indicated that, within their science methods course, they explored ACC related phenomena as well as climate communication. Within the SST programs, PSTs indicated that they focused on lesson planning around specific climate content that examined the content in isolation. The key distinction between these two groups was that the support that MSTs candidates reported was general while SST candidates reported specific examples. For example, an MST candidate described a support derived from their science methods course:

> *We take a Science Methods course that does touch on NGSS standards and other scientific, global goals that touch on climate change and environmental protection. We do have the opportunity to pursue projects that could involve climate change education, but no others that are explicitly provided for us*.

In comparison, an SST candidate in physics described their experience, "*Most of the activities used to teach us about how to construct lab experiments and lesson plans have at least partially climate change related, such as ocean acidification*."

PSTs also noted that their TEP needed further refinement in the resources and supports that they provided; this is discussed further below. For example, nearly half of the responses to the question that asked about the resources that the TEP provided were categorized as none. None, in this case, included responses that explicitly mentioned none as a response or responses that similarly described receiving no support. For example, an SST candidate in mathematics described a common response in this category, "*I have not received any information, resources, or tools regarding climate change education in this program thus far*." Responses that were categorized as none came from PSTs from all three subprograms: the multiple subject program (MST, n=6); the single subject program (SST) in mathematics (n=7), social science (n=3), science (n=1), English (n=3), and world languages (n=3); and the education specialists program (EST, n=3).

Field Placements. From preservice teachers' responses (n=49) that discussed the enactment of ACC related curriculum in their placements, two categories were identified. These categories were traditional curricular materials and underrepresented curriculum materials. Traditional curricular materials were defined as those that were focused on addressing state standards and were teacher centered. Underrepresented curriculum materials were those that were interdisciplinary and integrated outdoor experiences.

Traditional curricular materials (n=27) that preservice teachers reported observing included videos and interactive modules, such as those from Amplify, a web-based curriculum. For example, a PST enrolled in the MST program wrote, "*Everything related to climate change has been through the Amplify Science curriculum. It generally has a unit related to life or environmental sciences that can be, or is, linked to climate change*."

Additionally, incorporating local resources was mentioned as a way to attempt to connect the curriculum to the students at their placement. The topics in the curriculum that were covered included the transformation of heat and energy, electric cars, ocean acidification, and the chemistry of ACC. These approaches were categorized as traditional due to the approaches and content being addressed reflecting that which are commonly undertaken in the classroom.

Few preservice teachers described underrepresented curriculum materials used to teach climate change education. Underrepresented curriculum materials (n=4) that were reported by PSTs at their placements included utilizing art as a form of expression when discussing ACC and building personalized terrariums to have students experience managing an isolated environment. One preservice teacher discussed outdoor programs such as Youth Outdoors and Project Wild Activities, which allowed students to be immersed in an outdoor environment that helped foster a connection to nature. Lastly, an SST preservice teacher in physics discussed supporting students to design engineering solutions that can help mitigate climate change, "*I have seen classes look at engineering designs which I feel I can use to have students design some devices or solutions that they believe could have an impact on climate change*."

In addition, a third category of none was recorded as well (n=18). In these responses, PSTs noted that they had neither seen nor used any curriculum materials related to ACC at their placement, either explicitly or implicitly. However, these PSTs did note that the opportunity to address ACC in their placements did exist. For example, a PST within the MST program noted that although their placement did not provide ACC related curriculum materials, there were possible ways to address it:

Currently there are none. Science lessons understandably revolve around curriculum standards but could also be expanded upon to discuss climate change. Additionally, within the school there is a significant amount of food waste, and this can be discussed regarding farming and impact on climate change.

PSTs in this final category again spanned all three subprograms: They included those from the MST program (n=6); the SST program in science (n=3), mathematics (n=4), social science (n=2), and world languages (n=1); and the EST program (n=2).

Future Classrooms. When prompted to respond (n=43) to what supports PSTs would need in order to enact ACC lessons in their future classrooms, preservice teacher responses were categorized into supports needed and unsure. The supports that PSTs reported ranged from general materials (n=22), to pedagogical supports (n=2), to professional supports (n=4), to relevance (n=8), to interdisciplinary material (n=1) that specifically mentioned integrating content across disciplines.

General materials were composed of financial support, online based platforms, books, lesson plans, curriculum, resources that could be tied to local communities, and subscriptions to educational science sites. One need that was highlighted was the ability for a curriculum or lesson plan to be easily incorporated so that a teacher could integrate it into their instruction without a heavy time investment. This was described by an MST candidate, "*Modeled lessons, access to digital and physical resources (that don't require too much prep), adopted curriculum that can easily be incorporated*." Construction materials were reported as well for the building and demonstration of engineering-based solutions.

Pedagogical supports included guidance about grade appropriate ACC related content and strategies for teaching ACC in the classroom. This category also included how to discuss

teaching the topic in the classroom while considering the parents of students. For example, an MST candidate described this need as, "*How to answer student's questions without stepping on parent's beliefs.*"

For professional supports, responses mentioned buy in from administrative staff, freedom to teach the topic by colleagues and administrators, and professional development for how to begin to address the topic in the classroom. More specifically, preservice teachers requested support in determining how to start teaching about ACC in their classroom when the topic is complex and vast.

Additional responses consisted of needing support to understand how to connect the topics that are impactful and local to their students to ACC. This category included receiving support in taking students on more field trips in order to build a connection with nature as well as support for incorporating more outdoor education activities. For example, an MST candidate described this need:

> *I come from an outdoor education background, so I can clearly see the difference between science/nature guided education and traditional classrooms…. I would like to see more opportunities for guided field trips, time outside, and immersive projects that allow students to deep dive into climate change issues and gain a better understanding*.

Finally, a handful of PSTs (n=6) reported being unsure of what supports they would need in their future classrooms to enact ACC curricula. Still, PSTs in this group included those from MST (n=3), SST math (n=2), and EST (n=1).

PSTs' Recommendations for their TEP Going Forward. From the questionnaire, PSTs also recommended different supports and resources (n=48) for TEPs to consider for

supporting future PST candidates to enact ACC related curricula. These recommendations were categorized into interdisciplinary curriculum (n=11), general supports (n=11), content of ACC (n=11), a new course (n=3), interactive activities (n=2), and culturally relevant activities (n=1). Additionally, an unsure category was created (n=8).

Interdisciplinary content responses included the TEP providing supports to be able to address ACC in other contexts and languages. This interdisciplinary content included the social sciences, issues of equity, and indigenous knowledges. This was described by an MST candidate, "*Videos or curriculum (in Spanish too because they have dual language immersion sites) for us to use in our classroom*."

Within general supports, PSTs reported that the TEP could provide additional curriculum materials so as to address ACC in the classroom. This included graphs of the history of climate change, sample curricula, or a definition of what climate change education is.

Additional PSTs recommended the TEP offer discipline specific content that was grade appropriate and targeted to their discipline; this contrasts with recommendations for interdisciplinary content discussed above. PSTs noted that a vast majority of content available was for certain disciplines, particularly biology and chemistry. This was described by an SST candidate in physics, "*I would suggest that the future physics cohorts have some more resources provided to them. Most of what was given to the science cohort relating to climate change focused more on chemistry and biology*. "

Several PSTs stated that the TEP needed an explicit class or dedicated seminar to cover some of the aforementioned categories for future TEP students. For example, an MST candidate wrote, "*I think it [ACC] is super important and we should possibly have a seminar on it! It is something that is more than just science so learning how to connect it in other*

subjects as well." Another MST candidate mentioned, "*Implementing this topic into a separate course in teacher education programs, it's so important*." A third MST candidate described a similar need, "*Having a seminar on it or having one science class dedicated to how to teach it. Even tying it in with social studies since they are connected*."

Interactive activities were described as curricula that allowed their students to be hands on. More specifically, two preservice teachers described the need to learn about activities that allowed students to go into their community to connect what they learned in their classroom to their lived experiences. One PST suggested organizing hikes in their communities in order to journal about their surroundings and to foster a connection with nature for their students.

For the content of climate change education covered in the TEP, PSTs advocated for a complete view of the issue that integrates interdisciplinary material, strategies for climate communication, fostering a connection to nature, and actions that their students may take to mitigate ACC. For example, when considering a complete view of the issue, an SST candidate in mathematics described this as follows, "*Needing to understand the general implications as humans and some more specific ways to integrate climate change education into various subject matter*." An MST candidate elaborated on the importance on being able to communicate the pressing nature of ACC not only to students but to teachers as well, "*Not everyone will fully recognize the depth of this issue, but it needs to start with the teachers. Teachers should recognize the depth of this issue to guide students in future lessons*."

Lastly, a need for culturally relevant activities and instruction was indicated by only one PST. An SST candidate in the life sciences described this need as, "*More indigenous ties to the environment and connecting students with the land they live on*."

Summary of Supports and Recommendations. Overall, some of the supports PSTs identified align with the core ideas discussed in the expert interviews, such as a reported need for interdisciplinary material and connections to indigenous knowledge. However, most of the supports PSTs identified from their TEP were centered on content and practices that could be considered traditional within the classroom. For example, when reporting the resources that they were provided to teach ACC, NGSS aligned material and pedagogical strategies were the most common responses. This is appropriate as these approaches are key in allowing students in the classroom to understand the science side of ACC and can be considered a strength of most TEPs. However, these approaches do not consider other aspects of ACC, such as the intersection of social, economic, and political areas of ACC.

This disconnect provides an opportunity to integrate additional approaches and content that are aligned with a framework for teaching to transformative individuals and considers ideas that are core to climate change education. Such additional approaches and resources include some of the less represented responses provided by PSTs, such as indigenous knowledge and outdoor experiences. One potential avenue to address this need is by considering a recommendation from several PSTs themselves: A seminar or class that is dedicated to ACC could provide an opportunity to incorporate more transformative approaches for PSTs to integrate into their classrooms. This recommendation, among others, offers this TEP changes to consider to further prepare their PSTs to enact transformative ACC related curricula in the future.

E. RQ3: Preservice Teacher Alignment with a Framework for Teaching Transformative Individuals

This section reports on findings from an analysis utilizing codes that were derived from the teaching transformative individuals framework. This analysis was conducted on the open-ended responses that PSTs provided from select items in Table 9. These items included numbers 16, 18, 19, and 21. These items were chosen because they asked PSTs about their insights and recommendations derived from their experiences and interests. This analysis is differentiated from the analysis considering supports due to an explicit focus on the alignment with my framework, rather than on a categorization of TEP supports and recommendations. Overall, I found that less than one-third of PSTs' responses to each of these questions aligned with my transformative ACC framework.

To elaborate, item 16 considered the responses PSTs provided that were associated with how their TEP can support future cohorts. From the responses provided by the PSTs, I focused on those that described pedagogical supports/activities. In evaluating this subset of responses, I further identified 31% as aligned with the TTI framework. These responses were categorized as recognizing social justice science issues, social context, youth as transformative individuals, civic engagement, and culture as a tenet of teaching

As one example, an SST candidate in life sciences described how programs should consider social justice issues, "*I would recommend we spend time talking about how to address and get students to engage with equity issues around climate change*." As a second example, an MST candidate described a recommendation for TEPs to consider social contexts when addressing ACC in the curriculum. "*How to/practice with integrating climate change education into subjects outside of science, like having discussions in language arts, learning about climate change policy in history etc*." This response considers the social

context of ACC by mentioning the subjects outside of science. In this way, considering the social context integrates an interdisciplinary approach.

Item 18 asked PSTs to consider what supports they would need from their future schools in order to implement climate change education in their classroom. From the 43 total responses, 19% were coded as aligned with my TTI framework. These responses included recognizing social context in teaching and culture as a tenet of teaching. A common theme from the social context code was the consideration of the local communities to have ACC be personal and relevant for students.

As one example, a candidate in the MST program described this connection, "*I would need more information about how climate change affects their [students'] community, then the county, then state, then country, and world and so forth*." As a second example, when describing culture as a tenet of ACC teaching, an SST candidate in science offered their perspective, "*More indigenous ties to the environment and connecting students with the land they live on*."

For the purposes of research in climate change education, item 19 asked PSTs to consider what they believed should be considered by science education researchers. From the 42 responses, 19% were coded as aligned with my transformative framework. This subset of responses spoke to youth as transformative individuals, community as a source of knowledge, social justice science issues, social context in teaching, and culture as a tenet of teaching.

When describing youth as transformative individuals, for example, an EST candidate focused on the implementation of habits of students, "*Supporting students with resources on how to change their habits that impact climate change and how to implement those better in*

the classroom." Utilizing the community as a source of knowledge was explored by an SST candidate in English, "*Considering culture and the intersectionality of the population of students this is being taught to*."

This is further supported through item 21. Through this item, PSTs were provided the opportunity to recommend topics for consideration in studies similar to the present one. From the 15 responses recorded, 20% were aligned with the framework. These responses were coded as youth as sources of knowledge, recognizing social context in teaching, and youth as transformative individuals.

When examining youth as sources of knowledge, an EST candidate (Extensive) described considering what can be student driven, "*What did you see as student implemented in classrooms that taught you anything about climate change?"* For recognizing social context in teaching, an SST candidate in the sciences mentioned the interdisciplinary aspect of ACC, "*I think there should have been a question in the first part about what interdisciplinary approaches to climate change education we had been exposed to*." Lastly, an SST candidate in the sciences described considering integrating the stories of what other youth have done in regard to mitigating ACC as a source of knowledge, "*Any question asking about exemplifying same age peers, and what they are doing to help solve the climate change crisis*."

F. Summary

The results presented in this section provide different areas that TEPs can focus on to further support their PSTs in enacting ACC related curriculum. These areas include interdisciplinary aspects of ACC, discipline specific content, and strategies for understanding what climate change education is and what the goals of its curricula are. Additionally, the results described here convey that, when provided the opportunity, PSTs are interested and

receptive to material that is aligned with a transformative framework. The responses that PSTs wrote that align with the TTI framework recognize that social context and culture among other factors need to be considered within the classroom when addressing sociopolitical issues such as ACC. However, at this time, there were very few examples that align with the framework. Next, the results indicate that content is still the primary focus of any curricula related to climate change education in TEPs. However, as indicated by the responses of the PSTs, they are also receptive to opportunities to extend beyond content. Furthermore, the results indicate that PSTs feel agentic in enacting core ideas of climate change education, but report that they need further support in fully understanding what climate change education entails.

VII. Discussion

This study investigated the core ideas of climate change education and the agency that preservice teachers reported they had in enacting these ideas. Through the use of expert interviews, a collection of ideas that are core to climate change were identified. The experts drew on their expertise from the areas of climate science, education, politics, communication, and activism to construct these ideas. These core ideas are as follows: building community, climate communication, interdisciplinary approaches, localization, an emphasis on solutions, establishing an early connection to nature and empowering students as agents of change through transformative knowledge, providing a support system around the teacher at all levels of implementation, and exploring the connection that a teacher has with anthropogenic induced climate change (ACC) and nature.

Drawing from these core ideas, a questionnaire was developed that was administered to preservice teachers to understand how they perceived their agency in enacting these ideas. The results from the questionnaire indicated that (1) preservice teachers (PSTs) are agentic towards enacting core ideas as identified, (2) support is needed for teachers to better understand what climate change education fully entails, and (3) PSTs additionally need support in enacting transformative principles as described in the Teaching for Transformative Individuals (TTI) framework but are receptive to the idea of embracing these principles.

Bringing together the findings from the two phases of this study allows for recommendations that can further support the core ideas for climate change education, the teacher agency that facilitates the enactment of climate change education, and the transformative framework that contextualizes students as agents of change against issues such as anthropogenic induced climate change. Recommendations for each of these three

areas are presented below. I next turn to outlining implications for teachers, teacher educators, and researchers. For teachers, the implications provide strategies for incorporating the core ideas identified in the classroom. For teacher educators, the implications provide recommendations that can potentially be integrated into teacher education programs. Lastly, for researchers, the implications provide new directions for research to further examine the findings identified in this study. I conclude this chapter with a discussion of the current study's limitations and directions for future research.

A. Core Ideas for Climate Change Education

From the interviews, the core ideas that were identified by experts are outlined in Table 10. These ideas were grouped by the category that they were intended to support. A key distinction from the ideas identified in this study and similar work that has examined approaches and ideas to climate change education is a de-emphasis on the content of climate change. More specifically, the ideas in this study focused on areas that are not historically considered for the science of ACC. Most existing work that has examined how to support the facilitation of curricula that is related to ACC has traditionally considered the science concepts and ideas that both teachers and students struggle to understand.

To expand on key ideas in my literature review, with regard to teachers' understandings, Plutzer et al. (2016) conducted a large-scale survey of middle and high school teachers and found that there was a large percentage of teachers who were unaware of the consensus that scientists have regarding ACC. Hestness et al. (2014) summarized the alternative ideas about ACC science-related topics that are commonly held by both preservice and in-service teachers. These alternative ideas included confusion about the difference between weather and climate, the impacts of ACC on the biosphere, and the role of other sources of energy on

ACC. Similar studies have found alternative ideas about ACC that teachers hold include misunderstandings about the greenhouse effect, the ozone layer, and the role of pollution with ACC (Dove, 1996; Ekborg & Areskoug, 2006; Lambert et al., 2012; Papadimitriou, 2004).

Similar work that has been conducted with students also utilized the science of ACC as the focus. For example, Schuster et al. (2008) examined 11th and 12th grade students' ideas by having the students construct concept maps using terms that scientists deemed important to understanding ACC. The authors found that some inconsistencies were conveyed by the students with regard to the role of alternative energies and the role of greenhouse gasses. In their examination of the literature surrounding student ideas about ACC, Shepardson et al. (2012) found six reoccurring themes of student alternative concepts. The six themes were the following: causes of ACC, greenhouse gasses and the greenhouse effect, ACC in general, the difference between climate and weather, the relationship of the carbon cycle and the greenhouse effect, and the impacts of ACC. These concepts were all found to be challenging for students to understand. These findings about student ideas are also consistent with the work conducted by Jarrett and Takacs (2020). In their study, the authors administered an assessment to identify student ideas about key scientific concepts underlying ACC. They found that students had limited understandings of the carbon cycle, communicated inconsistencies about the composition of greenhouse gasses, and did not incorporate other aspects of ACC into their responses to its implications.

The purpose of such studies discussed above was to identify what science ideas teachers and students had difficulty in understanding in order to design curricula that could support and develop their understanding of these ideas. However, as noted by these studies,

alternative ideas about concepts that are core to climate science and understanding ACC persist. As such, a need to consider approaches outside of those that are solely focused on the science of ACC is present. This has led to more recent work in support of developing ACC related curricula by focusing on individuals' beliefs and attitudes that are connected to ACC. For example, in Kunkle and Monroe (2019), the authors administered a survey to high school teachers in order to determine how their worldview impacts their attitudes towards ACC. Their results indicated that if a teacher had a more conservative worldview, they tended to have a negative outlook towards ACC. Zummo (2020) conducted a similar study with high school students and reported similar results with students who were identified as having a conservative worldview and were more likely to reject ACC.

In addition to considering worldview, studies that de-emphasize content also consider the social context of individuals when examining ACC related content. Hestness et al. (2019) examined the link between student sociocultural activities and understandings of ACC. To do this, the authors administered an informal assessment, collected drawings from the students about what they think climate change is, and interviewed them about their answers to the assessment. Based on the results, the authors concluded that student participation in communities within and beyond the world of school did appear to inform their thinking about climate change. In particular, their interactions with media and their previous school-based learning experiences appeared to most strongly inform the ideas they brought to their science classroom. This led the authors to conclude that viewing student climate change understandings as a product of the unique sociocultural activities in which they are already participating in provides a valuable foundation for planning science learning experiences. Additionally, the authors emphasized that educators should be informed of the need to

develop pedagogical approaches that emphasize linkages between ACC and the communities and activities that matter to their students.

Furthermore, Herman (2014) administered a survey to students to gauge how sociocultural factors and their perceptions of science's claims about ACC were associated with their willingness to mitigate ACC. The author found that different perceptions of actions led to either a decrease or increase in a student's willingness to conduct certain actions. For example, as personal sacrifice in one's lifestyle increased in order to combat ACC, the less an individual was willing to implement those actions. This notion held true for how students perceived the validity of a scientific claim. Additionally, the author noted that sociocultural factors, such as socioeconomic status and ethnicity, could outweigh other factors in certain situations, such as energy conservation, supporting tax initiatives, and lifestyle choices. Thus, the author recommended that fostering reasoned engagement with ACC requires not only contextually teaching and assessing how and why scientific claims are valid, but accounting for how sociocultural factors can significantly impact decision making as well.

Through studies that consider the context of an individual, key practices have been identified for effective teaching for ACC. These practices include having engaging curriculum that creates active learning (Anderson, 2012) and contextualized activities (Monroe et al., 2019). In their article, Anderson (2012) noted that understanding of ACC can occur through "sustained, active learning activities" (p.198). As another example, Flora et al. (2014) incorporated this approach of actively engaging their students by implementing an "edutainment" approach. Edutainment involves incorporating educational content from a domain, such as ACC, with some form of popular entertainment (Singhal et al., 2003). Examples of this include using television shows or social media campaigns to convey

information. The authors were interested in utilizing edutainment in order to examine if they could improve knowledge and attitudes about ACC through this method. From their results, the authors noted that student knowledge, attitudes towards the issue, and ACC related behaviors all improved from the baseline assessments. Other methods that have been successful in providing engaging instruction centered around ACC include inquiry-based approaches, debates, small group discussions, hands-on labs, and field trips (Alexandar & Poyyamoli 2012; Jacobson et al., 2015; Karpudewan et al., 2015; Reinfried et al., 2012; Theobald et al. 2015).

A key point for most of these studies are the social aspect. Students are allowed to work together and through this are allowed to share information and come to conclusions together. For example, Theobald et al. (2015) implemented a flipped classroom in order to facilitate completion of an ACC related worksheet. This setting allowed for small groups to guide the discussion and kept the students in an engaging environment. This focus on engaging individuals was not just isolated to students. Hestness et al. (2017) incorporated a social aspect in their work with science educators by having the teachers work together in a professional development unit that was ACC centered. The teachers in their study worked together to determine how to best use learning progressions in their curriculum to address ACC. The authors noted that through this inquiry-oriented active setting, the teachers appeared to broaden their pedagogical understandings of teaching science related to ACC. Other practices that have been noted as effective strategies for teaching social issues such as ACC include interactions with climate scientists, materials that allow students to identify their own biases and misconceptions and conducting projects that allow students to engage in environmental work in their own community (Monroe et al., 2019). Thus, allowing students

and teachers to be engaged, either through visual, auditory, or social work, is a foundation for successful ACC related curricula/interventions.

The contextualization of information is key as well to facilitate successful practices in climate change education. Zangori et al. (2017) integrated a modeling-based unit that incorporated the experiences of their students. The authors did this by contextualizing their unit around a prairie that all of the students in their study had visited. From there, the authors had the students build models explaining the carbon cycle in the context of the prairie. From their study, the authors concluded that contextualizing their unit around their students' experiences and a global issue such as ACC supported the model-based explanations derived from the students. Bofferding and Kloser (2015) also utilized contextualization in their work examining student understandings of mitigative and adaptive behaviors. The authors did this by focusing on behaviors that were relevant to the student population that they were working with. To elaborate, as the population that they were working with lived near the California coast, the authors focused on behaviors that directly had implications with rising sea levels. The results of their study indicated that although the students still did not have a full understanding of adaptive and mitigative behaviors, the behaviors that were related to rising sea levels were remembered the most often. Additional studies show that if contextualization is considered for work associated with ACC, positive results are seen with either increased content knowledge, increased awareness of individual actions that can impact ACC, or an increased awareness of seeing ACC as an important issue (Alexander & Poyyamoli, 2012; Cone et al., 2012; Hallar et al., 2011; Leigh, 2009).

These articles show that an important aspect of an effective curriculum that is ACC centered considers context. This context can be in the form of the environment, student

background, or social aspects. However, there is room for improvement within these practices, most notably in the communication of ACC. For example, Wibeck (2014) stated that the communication of ACC related information has been identified as a key component in practice because of the power that framing can have. For example, the frame of scientific uncertainty that is reported by select news outlets and newspapers can lead to false impressions that climate sceptics are as credible as scientists (Schweitzer et al., 2009). For students, this can leave impressions that the scientific consensus about ACC is doubtful, which can then make learning about ACC in the classroom more challenging. Communication is also an issue because, although ACC awareness has increased in many countries, not much change has derived from that awareness (Whitmarsh et al., 2011).

Some of the core ideas identified from this study, then, align with what has been recommended as effective practices as described in previous studies that highlight active learning and contextualization. For example, the ideas that were identified for the classroom align with the studies that call for contextualization through localization. Other ideas, such as interdisciplinary material, an emphasis on solutions, and communication, have been described before in similar capacities through calls for research that can examine these concepts in the classroom (Irwin, 2020).

However, the ideas in this present study also advocate for the need to build community within the classroom. Through this use of community, ACC related curricula can be first anchored to a point that is localized and can then be expanded to other levels. The community within the classroom can additionally be a unit to integrate the other core ideas. The concept of community is not solely considered within the classroom, however, incorporating the community that the classroom resides in is critical. This has been noted to

be an important aspect in areas that integrate the concepts of culturally relevant pedagogy (Ladson-Billings, 1995), but are not as fully developed within areas that historically cover ACC (Dimick, 2012). Considering the contextual nature of the students and teachers within the classroom connects to this notion of community as well. As noted through studies such as those from Herman (2014) and Hestness et al. (2019), context can include beliefs and supports that these groups bring into the classroom. By utilizing these contextual factors, stakeholders such as teachers and students can identify the areas of ACC that are relevant to them.

Further, this consideration of the contextual factors surrounding students and the teacher are highlighted in additional ACC core ideas. When considering the context of a student, the connection to nature that they may or may not have will influence how they perceive their agency and their connection to ACC. Christensen and Knezek (2015) initially described this in their work with a survey that measured students' beliefs and intentions toward the environment that was focused on ACC. However, what this present study further develops is the consideration of the connection to nature that students have. This connection extends to the one that teachers have as well as listed in the core ideas. When considering the context of teachers at their schools, this has been described in work such as Martin (2020), who examined professional teacher agency that is influenced by a teacher's environment that is composed of domains such as colleagues and their administration. By considering how the contextual environment of a teacher can influence their enactment, topics such as ACC can be better supported by having teachers being connected to their environment instead of being impeded by it.

Ultimately, through the use of the ACC core ideas presented in this study, the practices that have been previously identified in other studies can be further developed. Utilizing a focus on the community within and outside of the classroom allows for curricula to be anchored to a meaningful place. Additionally, considering all the contextual influences that teachers and students bring with them into the classroom can also provide an avenue to bridge ACC related curricula with context of these individuals. By taking these perspectives into consideration, the field of climate change education begins to move beyond a strong focus on the content of ACC and integrates the external factors that influence ACC as well.

Table 10

Core Ideas for Climate Change Education

Grouping Theme	Core Ideas
Classroom	Building community, climate communication, interdisciplinary approaches, localization, and emphasis on solutions
Student	Establishing an early connection to nature and empowering students as agents of change through transformative knowledge
Teacher	Providing a support system around the teacher at all levels of implementation and exploring the connection that a teacher has with ACC and nature

B. Teacher Agency and Climate Change Education

A key finding that PSTs reported was a lack of an understanding of what climate change education entails. This lack of understanding can influence the agency that a PST perceives they have in enacting curriculum that is related to ACC. This disconnect between wanting to enact ACC related curricula but not clearly understanding what it entails can be for different reasons. For example, McGinnis et al. (2016) explored how different stakeholders within science education viewed the roles and responsibilities of themselves and others in climate change education. This suggests that the PSTs in my study potentially could not be clear on

their role as an educator of climate change education. Another potential reason could be the lack of time PSTs reported that they spent on the topic. For example, one of the supports that PSTs reported was a need for a dedicated class or seminar on climate change education. This suggests a potential need to further prepare preservice teachers in being agentic towards ACC related curricula by providing them with more exposure to the depth and breadth of topics in climate change education.

Next, the areas that preservice teachers reported they had the most agency in were in empowering their students and integrating ACC related curriculum into their content. Similar results were found by Borgerding and Dagistan (2018) in their investigation of preservice teachers' perceptions of addressing controversial issues within the classroom. In their study, the authors found that PSTs reported implementing certain controversial issues within their classrooms, including ACC. This finding aligns with what PSTs reported in this study, as 79% agreed that they will enact ACC related curricula. However, PSTs did report lower consensus in other areas when asked about their agency for their implementation. These areas were collaboration with other instructors and their ability to integrate activities or projects that are ACC centered that place their students as transformative individuals. These latter findings suggest that PSTs need further support in their ability to develop and understand innovative approaches required to enact empowering ACC related curricula. Tolppanen and Karkkainen (2021) reported a similar finding when working with preservice teachers in order to understand how these individuals perceived the mitigative actions needed for ACC. From their results, the authors indicated the PSTs needed further support in fully understanding how the intersection of different areas such as economics and politics are interconnected and

are needed for meaningful change. This need indicates that teacher education solutions are required in order for PSTs to be able to enact change.

Anderson et al. (2020) described a potential solution to expanding preservice teachers understanding of empowering approaches to teach ACC through an examination of teacher creativity. This creative potential within teachers would allow for the generation of new, useful, and meaningful ideas that can transcend practice boundaries (Runco & Jaeger, 2012; Martin, 2020). As such, by supporting PSTs in developing their creativity, innovative ideas that stem from interdisciplinary connections and empowerment projects can potentially be developed. Additionally, examining the professional spaces that PSTs are located within could be an area to further examine. For example, Birt et al. (2019) and Windschitl et al. (2021) found that the culture and view of education a school embodies influenced the agency an instructor had when enacting curricula within their classrooms. This presents an opportunity to further explore the placements of PSTs, if they view disciplines as siloed, and how much collaboration PSTs believe they can engage in as a result.

Continuing to further examine how to support teacher agency toward ACC related curricula is critical. The results from this study provide some insight into what areas PSTs reported they needed further support to continue to develop their agency. However, additional work is needed because having empowered teachers not only allows for innovative approaches to be enacted, but supports student agency as well (Maulucci et al., 2015); I discuss this connection further below. Furthermore, through supporting teacher agency within the classroom, new reform-based efforts can be sustained for longer periods of time (Balgopal, 2020). This support could be through more dedicated time to ACC in TEPs or

through fostering an affective connection to ACC (Lombardi & Sinatra, 2013). As such, further research is warranted.

C. Teaching for Transformative Individuals

When utilizing the Teaching for Transformative Individuals (TTI) framework to analyze the responses received by the PSTs in this study, a number of insights were identified. These insights suggest that although PSTs reported that they wanted to enact curricula that integrates ACC, they needed further support in utilizing perspectives that are derived from the TTI framework. For example, on average, only 22% of the total responses provided by PSTs were aligned with transformative practices. This finding reiterates what has been found in other literature that has examined the intersection of social justice within the area that ACC is traditionally taught, science education. Dimick (2012) described this in their article that investigated how social, political, and academic empowerment were or were not enacted within classrooms. From their findings, the author concluded that empowerment through social justice issues is a process that teachers need continued support with, in order to fully be able to enact them.

However, when PSTs did provide responses that were aligned with the TTI framework, the most common response was reflective of a recognition of the social context of teaching. The influence of social context reported as the most common response aligns with similar work that has examined teacher responses for successful enactment of ACC related curricula (Reis, 2014). Other responses included a recognition of culture as a tenet of teaching, youths, and community as a source of knowledge, and youth as transformative individuals. When prompted to respond to what areas PSTs might integrate within ACC related curricula, the six responses that PSTs self-generated from the “other” response option aligned with social

justice issues as well. Collectively, then, PST responses that were aligned with the TTI framework indicate that at least 9% do recognize a need to integrate their content topics with ACC. This recognition is important as other work has indicated that the valuing of social justice issues and the critical lens, they require by teachers can lead to their students becoming more socio-politically aware of the links between science and social change (Upadhyay et al., 2020).

Holistically, these findings suggest that PSTs needed additional support in order to expand what they considered to be transformative practices that align with a framework for student empowerment. One way to support this is through action projects (Dimick, 2012). This emphasis on action is a key concept of the TTI framework and, as such, is a potential area for integration into a social justice aligned classroom. More specifically, by emphasizing and integrating student activism within the classroom, a teacher can develop a sustained commitment to social justice science issues like ACC for their students (Upadhyay et al., 2019).

Student activism in other disciplines has been analyzed (Rhoads, 2016) and has a rich history of being one of the sparks that brings about social change (Wheatle & Commodore, 2019). There has been work that has investigated what factors influence and support a sustained engagement to different forms of activism within science education that can provide insights into how to support teachers in fostering this commitment to activism in their students. For example, when examining what factors impact individuals who partake in citizen science, Philips et al. (2018) reported that prior behavior, emotional connections, learning, and social connections to the project all influenced how engaged individuals were with the project that they were involved in. Additionally, Fisher (2015) examined the

trajectories of climate activists. From his results, the author was able to describe what factors impacted the activists that participated in his study. These factors were a conscious commitment to climate activism, a concern for nature and social justice, and a dynamic commitment to the youth movement and not just the issue. These aforementioned factors are all areas that can be the focus of future work that supports teachers in developing their students to be transformative individuals who are empowered through action. Another potential avenue is through highlighting the success of their peers in being agents of change. For example, Trott (2021) examined how students in the classroom can be positioned as transformative in their actions toward mitigating ACC by being shown how far youth led movements have come and the impacts that they have. Furthermore, focusing on developing skills that may not be traditionally thought of when considering ACC can be vital in empowering students to become transformative individuals who have a commitment to social justice science issues. Levrini et al. (2020) described such an approach through their examination of future scaffolding skills. Through these skills, students are able to perceive their actions in the context of the future and what their present actions mean for future generations. Finally, fostering political will is another avenue that can offer insights into empowering students to be agents of change (Treadway et al., 2005).

Activism is complex (Vestergre et al., 2017), but as reported in other studies, preservice teachers in this study were interested in encouraging and supporting student activism and empowerment but needed further support in finding issues that are relevant to their students as well as finding time within their prescribed curricula (Reis, 2014). One potential support is through future professional development opportunities where teachers are given strategies that can engage their students and allow them to understand the perspectives of their students

when it comes to issues of activism (Cebrian-Robles et al., 2021). In future research, where a commitment to supporting and developing transformative individuals is centered, additional approaches can be identified.

D. Implications

The results from this study have implications for teachers, teacher educators, and researchers. Each of these areas are discussed in the following subsections.

1. Teachers

Utilizing community both within and outside the classroom is imperative for the facilitation of ACC related curricula. The core ideas for climate change education identified by the experts in this study present different areas that can intersect with community. By integrating communication, teachers can address different strategies for discussing ACC related issues with members of their classroom and local community. These issues may include pushback from parents or students in the classroom or how the impacts from ACC may influence community sites. By utilizing community, these issues can be contextualized within the community to provide a connection to points of contention. For example, if ACC is perceived as an abstract idea, the impacts can be directly tied to a local site to provide local evidence of ACC's consequences. Additionally, a focus on community allows issues such as climate anxiety to be addressed through an initial localization of an ACC related issue to an immediate space. By centering on a local setting within the community, ACC can be presented as immediate instead of as a global challenge to counteract an overwhelming sense of climate anxiety.

This integration applies to the other core ideas of interdisciplinary materials and an emphasis on solutions. Through the focus on community, any material presented alongside

the other core ideas present opportunities to empower students to be transformative individuals. This is facilitated through the incorporation of social justice science issues that are contextualized in the lived experiences of students. Thus, the core ideas presented here, when integrated with one another, present an opportunity for teachers to integrate the lived experiences of their students with the ACC related content of the classroom.

2. Teacher Educators

The results presented here offer a set of recommendations for teacher educators and teacher education programs to consider. The recommendations that were provided by the preservice teachers include different areas to target when it comes to courses offered, the content covered in those courses, and the impact of the affective domain. When considering the courses offered in teacher education programs, having a dedicated seminar or course that addresses some or all of the ACC core ideas identified in this study appears beneficial. Additionally, a dedicated course to ACC would provide a space for all candidates to develop and present interdisciplinary material to one another.

The content covered within courses that do address ACC also offer an opportunity to incorporate the recommendations that were derived from the preservice teachers. For example, a key area to focus on is the integration of social justice issues. These issues provide a focal point to anchor the content of ACC whether it be science or a related area. Furthermore, supporting teachers in their ability to collaborate with other instructors is another focal point for teacher educators to support. This support in collaboration would further provide insight for preservice teachers in feeling empowered to develop interdisciplinary content.

Lastly, focusing on the affective domain of preservice teachers is integral as well. As previous work has shown, by connecting to the affective domain, issues that can be perceived as vast and abstract can be made tangible (Lombardi & Sinatra, 2013). This connection extends to the beliefs that individuals, such as teachers, bring into the classroom about issues such as ACC. By allowing preservice teachers to confront their own beliefs about ACC and have them critically examine how those beliefs may impact their instruction, it will give them experience as to what a similar process may look like with their own students. Moreover, this focus on the affective domain within TEPs provides an opportunity to integrate aspects of the socioemotional contextual reality of their candidates into instruction. Through this approach, preservice teachers can garner experience into how this focus on emotions can provide new insights that a focus on the science of ACC solely would not.

3. Researchers

This present study contributes to the current work that is examining climate change education beyond a sole focus on the science of ACC. For example, Irwin (2020) advocated for a focus on personally relevant and meaningful information when addressing ACC in the classroom. The core ideas presented here further develop this notion of personally relevant and meaningful information through the recommendation of an explicit connection to the community within and outside of the classroom when examining ACC. This connection to community is facilitated through a focus on social justice science issues. These issues provide a connection to the science of ACC through the lived reality of students. It additionally provides meaning by being an issue that is derived from the community that the students reside in. In this way, this present study further develops the recommendations from Irwin (2020) and provides an additional focus for science education researchers.

The work here also contributes to the call put forth by Ladson-Billings (2014). In her article, the author called for work that further develops the framework that she described almost two decades before (Ladson-Billings, 1995). This present study addresses this challenge by describing culturally empowering pedagogy. This pedagogy incorporates the perspectives described in culturally relevant and sustaining pedagogy, but further develops these approaches by focusing on empowerment as an additional tenet of education. Through the consideration of culturally empowering pedagogy, civic issues, social justice science issues, youth empowerment, were able to be integrated. Through this integration, the teaching for transformative individuals framework was developed. This framework extends teaching that aims to incorporate culture in the classroom by focusing on the empowerment of students to address issues such as ACC. As such, the TTI framework is immersed in culturally empowering pedagogy that seeks to not only sustain culture (Paris, 2012) but to empower students as well.

This study adds to the growing literature that is examining how agency influences the enactment of curriculum for preservice teachers. For example, Anderson et al. (2022) examined how agency impacted creativity within the classroom. From their study, the authors found that through explicit support, teachers were able exert their agency for integrating creative practices into their pedagogical approaches. Additionally, Windschitl et al. (2021) focused on the agency preservice teachers have when they are conducting their placements in schools. It was reported that the congruence between the vision of teaching that their teacher education program held and that of their placement impacted the agency that the candidates perceived they had within their placements. The work presented here offers similar insights into how agency influences preservice teachers. From this study,

agency has a direct influence into what preservice teachers believe they are capable of enacting when considering ACC. This was shown through the topics that preservice teachers reported being able to enact and the areas that they reported needing further support on. The present work allows for future research to continue to consider how agency influences teacher enactment within the classroom.

Lastly, the work presented here adds to the literature that examines measurement. More specifically, to the literature that is interested in the construction of measurement tools within science education. The questionnaire that was described here was constructed for an area and population that are not well studied in unison. The iteration from this study provides a template for future studies that want to evaluate agency and social justice with preservice teachers

E. Limitations and Future Directions

There are a number of limitations to this study. First, the core ideas that were identified were derived from a pool of experts that may not fully consider the perspectives of other members of the professional communities that the experts are a part of. Due to this, themes that might have allowed for a different perspective on the ideas reported here might have been present that were not identified in this study. As such, future work could focus exclusively on the perspectives of different areas of climate and climate change education in order to identify a wider range of themes. These additional themes would allow for a comparison with the results presented here.

Second, the sample utilized within the questionnaire can only provide insights for the sample considered. As such, the results from the questionnaire are not generalizable to a larger population of preservice teachers. To elaborate, the responses collected in this present

study are contextualized within the community that the PSTs are located in and as a result may differ from candidates that are located in a different region of the country. Additionally, the preservice teachers from the population sampled were primarily composed of MST and SST candidates. As such, this leaves the perspectives of EST candidates not fully represented. This presents an opportunity for future research to be conducted with candidates that intend to be teachers in special education classrooms.

Third, a second iteration with a larger population would help to further reinforce the findings reported here and would help further refine not only the questionnaire itself, but the responses as well. The results presented here are from a first iteration of the questionnaire that was administered. Because of this, additional information could be integrated into the questionnaire to potentially refine the items. With additional iterations of the questionnaire, the validity argument of the survey could be further refined in order to strengthen the questionnaire. A larger sample size would also allow for additional interpretations to be made from the use of an IRT model that was utilized in this present study. Furthermore, the Likert-scale questions could be further refined in terms of their content to derive more specific information from the participants. Moreover, shifting from Likert questions to other forms of questions could provide additional insights that are not readily available through the Likert form.

A fourth limitation was that the present study primarily considered the perspectives of preservice teachers. As such, the responses that they provided were not considered in conjunction with those of their teacher educators or their cooperating teachers (CTs). This presents an opportunity for a future study that considers the perspectives of all three sets of

stakeholders to understand how the responses from PSTs align (or not) with those from their teacher educators and CTs.

Lastly, the perspectives reported here are exclusively from PSTs. Because of this, the responses collected were from a point in their training that was before they were fully immersed in their classrooms as instructors of record. This shift from preservice to in-service should have an impact, changing or influencing their responses that were collected in this study. Investigating this potential shift in responses presents another direction that would be interesting to investigate in the future.

F. Conclusion

Climate change education is an area that is complex and requires the perspectives of various experts. The reason for this is that climate change education needs to have impact in order to empower and motivate individuals to take action in mitigating ACC. Additionally, as ACC is an issue that is sociopolitical, a focus solely on the science of ACC is not enough. The results presented in this study support results that have been previously found that recommend a need to consider the context of the classroom and the individuals within it. However, what additionally needs to be considered is the community within and outside of the classroom. This consideration of community ties into social justice issues that can foster transformative individuals.

Preservice teachers indicate that they are ready to enact ACC related curricula that can foster students as transformative individuals by incorporating their community and the social issues that can be found within them. However, as indicated in this present study, further support and resources are needed from all aspects of their teacher education program so that preservice teachers can indeed realize these goals. By providing this support, we can begin to

prepare our preservice teachers to not only foster transformative individuals but to be such individuals themselves.

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Appendix

Appendix A

Interview Protocol

Thank you for agreeing to be interviewed today. I am interviewing you as part of my research that is examining how can we better support teachers to empower students as agents of change, with a specific focus on climate action. The interview should last approximately 45 minutes. It is divided into 4 parts. Do I have your permission to record the interview?

General interest in climate change

The first few questions are about how you promote climate action in your own research and/or teaching.

1. Can you tell me about your first experiences with teaching about climate change issues, whether that be in the classroom, in an informal space, or somewhere else?
2. Caring about the future of the planet, providing opportunities for future generations to live on a sustainable planet are some examples that university faculty mention when asked what motivated them to take action against climate change. What about you- what motivated you to act to against climate change in your personal life?
3. In your opinion, what are some of the factors that can encourage an individual to take action against climate change?
    - What are some factors that can cons an individual's willingness to take action?
4. In your experience, what are some mitigative/sustainable behaviors or actions that can be presented as achievable goals for individuals who are interested in climate action?
    - What actions do you suggest in your own course(s)?

Role of education

These next few questions are about the role education, specifically the role K-12 teachers can fill in empowering their students to be agents of change against climate change. More specifically, these questions are how we can further develop K-12 teacher education to support future teachers to empower students.

5. What role do you think K-12 education can play in motivating or empowering people to act against climate change?

6. To build on that, in your opinion, what are some of the qualities that you think K-12 teachers should foster to empower students to be agents of change?
7. What are some of the approaches you think K-12 teachers should implement to empower their students?
    - How are these approaches similar to and different from what you do at the university level?
8. What are some of the resources you think K-12 teachers would need to enact the aforementioned strategies?
9. In the K-12 science classroom, what topics do you think can be integrated when covering climate change that are not traditionally addressed?

Climate communication

These next few questions are about the manner in which climate change and climate action should be communicated in the classroom by K-12 teachers.

10. What do you think is the message that K-12 teachers should try and convey when it comes to climate change?
    - For climate action?
11. What communication strategies do you think would be effective for K-12 teachers to teach to their students in order for them to be able to communicate about climate change to their peers or parents?
12. How do you think K-12 teachers should approach situations where a member of their classroom community (a student, colleague, or parent) are resistant to climate action instruction or activities?

Wrap-Up

Thank you again for agreeing to be interviewed. These last few questions are about any other insight you want to provide for the interview.

13. What is anything you would like to add about how we can support K-12 teachers to empower their students to undergo climate action?
14. What is something from your field that you think needs to be considered in future research concerning climate action by K-12 teachers and students in general?

That is the last of my questions! Thank you again. Do you have any questions for me?

Appendix B

Consent Statement

You are invited to participate in a research study. This study is seeking to understand how to better support preservice teachers in teaching about climate change. Participation in the research is voluntary. Consenting to this study does not require any additional activities or requirements beyond completing this survey. Consent allows us to analyze your responses to the survey to identify strategies for preservice teachers to implement. The completion of the survey should take no more than 20 minutes.

There are no known risks to your participation in this research and no known direct benefits to you. We hope that this research will help us develop high-quality instructional strategies for preservice teachers and will contribute to our understanding of how to best support teachers in teaching students about climate change.

All data collected by the project will be kept in a secure location in our research offices at the University of California, Santa Barbara. We will not share individual information with anyone outside of the research team. Computerized data will be kept in pass-coded computer files. Any potential identifying information will be stored in separate files from the data itself. All published materials will use aggregated data only—no individual participants will be identified. At the end of the survey, a tree will be planted in your name through https://onetreeplanted.org/, however, you can request to not have this occur. No monetary compensation will be given in lieu of the tree being planted through the website.

If you have any questions about the research, please contact me, Erik Arevalo, at erik_arevalo@ucsb.edu.

If you have any questions regarding your treatment or rights as a participant in this research project, please contact UCSB's Committee for Protection of Human Subjects at 805-893-3807 or by email:
orahshelp@research.ucsb.edu

Consent

1. I agree to participate in this survey
    a. Yes
    b. No

The following questions will ask you about your teacher education program.

2. What program are you in?
    a. MST
    b. SST
    c. Educational Specialist, Mild to Moderate
    d. Educational Specialist, Extensive

- Sub question if b

What subject are you focusing on?

a. Life Sciences
b. Physics

c. Chemistry
d. Earth Science
e. Social Science
f. Mathematics
g. English
h. World Language

3. Are you completing the bilingual authorization?
    a. Yes
    b. No

The following open-ended questions will ask you about what resources and tools your teacher education program has provided you and what could be further developed to support climate change education.

4. What information, resources, or tools have you been provided with in your program regarding climate change education?
5. What information, resources, or tools would you recommend the program address for future cohorts regarding climate change education?
6. What information, resources, or tools have you seen implemented in your placements that you think you could use in integrating climate change topics into your future classroom?
7. What information, resources, or tools do you think you would need from your future school in order to implement climate change education in your classroom?
8. What is something that you think our study should consider for supporting preservice teachers in integrating climate change education in teacher education programs?

The following questions will ask about your general attitudes towards and familiarity with climate change.

9. How connected did you feel to nature through your experiences growing up?
    a. Extensive
    b. Sufficient
    c. A little
    d. Very little
    e. None at all
10. How much do you know about climate change in general?
    a. Extensive
    b. Sufficient
    c. A little
    d. Very little
    e. None at all
11. In general, I think I have a moral duty to enact actions to mitigate climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
12. In general, I enact actions or encourage others to enact actions to mitigate climate change.
    a. Strongly agree

b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

13. In general, I think that individual actions can have a positive impact on mitigating climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
14. In general, I think that corporations and nations have a vital role in mitigating climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

The following questions will ask about your experiences in your teacher education program and how prepared you are to enact climate action strategies in your classroom.

15. At this time, I think that forming a connection with nature is important for my students.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
16. At this time, I think I can empower and support my students in taking action towards climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
    - Sub question if d or e: Please explain your response.
17. At this time, how much do you know about climate change **education** in general?
    a. Extensive
    b. Sufficient
    c. A little
    d. Very little
    e. None at all

18. Upon completing my program, I plan to integrate climate change related curriculum into my content.
    a. Strongly agree

b. Agree
c. Neutral
d. Disagree
e. Strongly disagree

- Sub question if d or e: Please explain your response.

19. If I were to integrate climate change into my content I would focus upon, select all that apply.
    a. The causes of climate change
    b. The consequences of climate change
    c. Mitigative actions against climate change and how to enact them
    d. Solutions for climate change
    e. Other
20. Upon completing my program, I plan to integrate social issues such as poverty and inequality of resources into my content related to climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
    f. N/A

- Sub question if d or e: Please explain your response.

21. Upon completing my program, I think I will be able to effectively collaborate with other content instructors to create interdisciplinary material related to climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
    f. N/A

Sub question if d or e: Please explain your response.

22. Upon completing my program, I think I will be able to foster a sense of community in my classroom centered around empowerment and student action towards climate change.
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
    f. N/A

- Sub question if d or e: Please explain your response.

23. Upon completing my program, I think I will be able to implement activities or projects that are related to climate change that empower my students to be activists and to create change in their communities.
    a. Strongly agree
    b. Agree
    c. Neutral

d. Disagree
e. Strongly disagree
f. N/A

- Sub question if d or e: Please explain your response.

24. Would you like a tree planted upon completion of your survey?
    a. Yes
    b. No

- Sub question if a, what email and name would you like the tree planted under? Or it can be anonymous as well

Thank you so much for your participation in the survey! Your responses are greatly appreciated and will be used to further develop climate change education throughout teacher education programs.

Appendix C

Tier 1

Teaching for Transformative Individuals (Student Agency)

Codes	Description
Civic Engagement	• Participant mentions engaging in or wanting to engage in work of influencing legitimately public matters using means within the existing political structure in their classroom - This includes deliberation, persuasion, collaboration, participation in legal politics, civil disobedience, and volunteering. Or working with some science-issue-related interest group, participation in citizen panels, or public forums to enact change through individual or collective means.
Use of scientific knowledge	• Participant mentions using science knowledge to help make a decision related to some public concern. Public concern includes areas where scientific expertise is often sought out and include public health, public safety, the environment, national security, and the economy, nearly all areas with established roles for government regulation and oversight
Production of science knowledge	• Participant mentions investigating or conducting work to examine how scientific enterprise is funded either privately or publicly
Shift in perspective	• Participant mentions wanting to or enacting a shift in their classroom from content to epistemology
Teacher engagement with community	• Participant mentions emerging themselves or engaging with the community of their students outside of the classroom
Social transformation through science education	• Participant mentions utilizing science education as a vehicle for social transformation
Generative themes	• Participant mentions utilizing social injustice issues that are local and personal for students in a community
Generative words	• Participant mentions their utilizing their students' actions or feelings towards those issues as an anchor for a social injustice issue
Conscientization	• Participant mentions having their students undergo reflection to consider their power in transforming their world

Youth as transformative individuals	• Participant mentioning their students being or supporting their students to be producers of knowledge, culture, and agents of change. These changes could be exemplified through support in changing or influencing student actions.
Social justice science issues	• Participant mentions utilizing issues that requires community engagement, supports content learning, and political clarity
Community as a source of knowledge	• Participant mentions that the community a student comes from is a resource for classroom content
Youth as sources of knowledge	• Participant mentions having their students be a source of knowledge for classroom activities
Culture as a tenet of teaching	• Participant recognizes culture being an integral part of teaching
Culture as deficit	• Participant mentions culture as a means for student differentiation
Recognizing social context in teaching	• Participant recognizes that social context plays an integral role in teaching and education whether that be student context or context to issues being taught in the classroom
Fostering classroom community	• Participant mentions developing a community within their classroom where students feel empowered to share ideas and contribute to conversations
Commitment to culturally empowering teaching	• Participant mentions integrating all or some of the tenets of culturally empowering teaching through a commitment to academic achievement, sustaining culture, recognizing the political nature of content, and the development of critical consciousness alongside empowerment
Barriers	• Participant mentions any barriers that they foresee or prevent them from enacting transformative practices
Other	• Participant mentions something that does not fit in with other codes
Deficit	• Participant mentions that individuals do not have a sufficient impact to enact change
Don’t Know/Unsure	• Participant mentions being unsure or doesn’t know how to answer the question

Notes:

Appendix D

Tier 2

Professional Teacher Agency

Codes	Description
Power in Actions	• Participant mentions that their actions in the classroom have power to influence their environment through different lenses - Autonomy - Reflexivity - Past experiences - Present context - Consideration for the future - Beliefs
Deficit perspective with agency	• Participant mentions that they do not believe they have agency within their environment
Transformative agency	• Participant mentions enacting practices that induce transformative learning that deviate from traditional classroom practices. These may include empowering students as generators of knowledge, emphasizing culture as a tenet of teaching, or embracing the community of their students outside the classroom, or connecting to social justice issues
Reproductive agency	• Participant mentions enacting practices that perpetuate the status quo in the classroom. These include being teacher centered, a focus on content, and isolating the content of the classroom.
Pressure to conform	• Participant mentions feeling a pressure to conform to traditional classroom practices either through their administrators, fellow teachers, or traditional responsibilities

Relational agency	• Participant mentions taking actions to integrate their content area with other content areas either on their own or through collaboration
Advocate for students	• Participant mentions being an advocate for their students or students in general to be transformative individuals
Connection to student community	• Participation mentions having or striving for a connection to the community of their students outside of the classroom
Disconnect with administration	• Participant mentions having an experience or lack of support from their administration that prevents them from exerting transformative agency
Mentor support	• Participant mentions having or received mentor support sometime in their training that supported them in being an agent of change through transformative agency
Experience	• Participant mentions experience as a factor that influences
Other	• Participant mentions something that does not fit in with other codes
Don't Know/Unsure	• Participant mentions being unsure or doesn't know how to answer the question

Notes: