RESET-ting Professional Development:

Fostering Mid-career K-8 Teachers' Identities and Actions

as Culturally Responsive Science and Engineering Educators

by

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ABSTRACT

This qualitative, design-based research study explored the design, implementation, and outcomes of a professional development for mid-career K-8 science and engineering teachers. The Responsive and Empowering Science and Engineering Teacher (RESET) professional development was designed to support teachers in developing role identities as culturally responsive teachers, change agents disrupting inequitable educational practices, and advocates of students' equitable access to and participation in science and engineering disciplines. Four mid-career K-8 teachers participated in RESET, which was embedded in a five-week summer program focused on solar energy engineering. The teachers engaged in activities designed to increase their knowledge of and pedagogical strategies for culturally responsive teaching. After each key event, teachers reflected on their experiences in terms of their role identities, including their purposes and goals, self-perceptions, beliefs, and perceived action possibilities for that role. Teachers also engaged in critical discussions examining how the strategies and practices might contribute to more equitable science and engineering practices.

An embedded case study design was used, with RESET as the focal case and the four teachers as embedded cases, to examine teachers' experiences during RESET and actions during the school year. I analyzed teacher surveys, semi-structured interviews, written reflections, audio recordings of the critical discussions, and researcher memos from during RESET and school year observations to determine the influence of RESET on teachers' role identity development and actions. I also analyzed a series of conjecture maps created to detail the design and adaptations of RESET to explore the extent to which RESET's targeted enactment processes and outcomes had been achieved and design and process conjectures had been supported.

Findings varied across participants, with all four participants at least somewhat achieving the targeted outcomes, indicating that all of the teachers' role identities were influenced by RESET. Three of four teachers translated their learning into actions as culturally responsive science and engineering teachers during the school year. In terms of RESET's design, several of the conjectures were supported or partially supported. Implications for the second iteration of RESET and for the general scholarship on professional development for mid-career K-8 science and engineering teachers are discussed.

Dedicated to all of my family and friends.

My journey over the past four years has included many ups and downs, twists and turns. I would not have made it to this point without an absolutely incredible support system. Thank you all!

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LIST OF ABBREVIATIONS

CRT	Culturally Responsive Teaching
DBR	Design based research
MESA	Mathematics, Engineering, and Science Achievement
NGSS	Next Generation Science Standards
NRC	National Research Council
PD	Professional development
RESET	Responsive and Empowering Science and Engineering Teaching
RET	Research Experience for Teachers
REU	Research Experience for Undergraduates
SEER	Solar Energy Engineering Research
STEM	Science, technology, engineering, and mathematics
YS HS	Young Scholars (High School)
YS MS	Youth Scholars (Middle School)

CHAPTER 1

INTRODUCTION

Students of color in US schools continue to experience educational inequities and injustices resulting from a combination of historical, social, political, economic, and educational practices and policies (Ladson-Billings, 2006). These injustices have included overrepresentation of students of color in special education and in disciplinary actions and have resulted in deficit-oriented beliefs and practices that are harmful to students of color (Souto-Manning, 2019). Specific to STEM disciplines, barriers to equitable opportunities limit students' access to and opportunity for "science empowered futures (e.g. higher paying jobs, a voice in environmental and health injustices)" (Calabrese Barton & Tan, 2019, p. 2). In short, inequitable science and engineering educational practices have led to many students (e.g., Native Americans, African Americans, Latine, females, LGBTQ+, and students with disabilities) being underrepresented and marginalized in STEM disciplines (NRC, 2015; Riegle-Crumb et al., 2010).

Providing equitable and socially just education to all students is the challenging - but essential - work educators must engage in. This work is challenging in part because the neoliberal agendas and policies in education often limit opportunities for equity- and justice-oriented educational practices (Picower, 2011; Sleeter, 2012). There continue to be racial disparities between teachers and students, with a racially-diverse student population generally being taught by White teachers (US Department of Education, 2016). Furthermore, according to Utt and Tochluk (2020), "too few [White teachers] have nuanced understandings of how their racial identity affects their teaching practices" (p. 126).

As important as it is, race is not the only aspect of students' sociocultural identities that teachers must attend to. "Racial identity cannot be disentangled from the experience of gender, sexual identity, wealth or class, citizenship, religious identity, ability or disability, body size, or any other core peripheral aspect of social identity" (Utt & Tochluk, 2020, p. 139). These overlapping identities, or *intersectionalities* (Crenshaw, 1989), interact in a variety of ways to perpetuate systems of oppression and inequality (Boveda, 2016).

Culturally responsive teaching (CRT; Gay, 2010, 2018) is one promising approach to help teachers to tailor their instruction to students' diverse intersectionalities, and to advocate for and support their students' learning in science and engineering disciplines (Brown, 2017; Wilson-Lopez, 2016). Culturally responsive science teaching has been shown to foster positive science identities, content knowledge, and scientific literacy for students of color (Carlone et al., 2011; Lee, 2004). Teacher PD can support teachers in learning to enact CRT (Brown & Crippen, 2016). Thus, this design-based research (DBR) dissertation study addressed how teacher professional development (PD) could be designed to foster mid-career K-8 teachers' role identities and actions as culturally responsive science and engineering teachers, change agents seeking to disrupt inequitable educational practices, and advocates of students' equitable access to and participation in science and engineering disciplines.

In this chapter, I begin with an overview of my own identity and specific roles, as related to this study, in order to position myself within the work. I then overview the specific problem this study aims to address, as well as the purpose and research questions guiding the study. The significance of this dissertation study, in terms of what it adds to existing knowledge and literature, is discussed next, followed by the definitions of key terms I use throughout this manuscript. Finally, I provide an overview of each of the chapters in this dissertation.

Researcher Roles and Identity

In this dissertation study, I held several roles, which are discussed in Chapter 3, but introduced here. I was the primary PD designer, facilitator, mentor, and researcher. Because I held such a range of responsibilities and because of the focus of the PD on issues of equity and social justice, it is important for me to provide some background information on how I, as a White female scholar and teacher, became interested in and passionate about this topic. I also seek to position myself within this work, not as an expert, but as someone who wants to help others work toward a solution rather than to be part of the problem.

My very earliest memories are filled with an awareness of "difference." I have two siblings who were born with medical conditions and "disabilities" that have shaped every aspect of their lives, and to a large extent, have also shaped the lives of the rest of the family (which includes myself, my younger sister, and my parents). My older sister, Lindsay, does not have many external, visible markers of disability. My younger brother, Michael, however, is paralyzed from the waist down and uses a wheelchair for mobility. Thus, for my whole life, I have seen the differences not only between individuals who are differently abled and those who do not have a disability, but also in how individuals with different disabilities experience discrimination and inequity in diverse ways.

I saw these inequities with my sister mostly in terms of educational access and professional success. Lindsay was only one grade ahead of me in school, so we spent most of our K-12 years in the same schools. She struggled with severe learning disabilities that made academics very difficult for her. I excelled academically. We were both devastated when educators (or anyone) made direct comparisons between us. I was not working harder or somehow a better student, and she was not lazy or unmotivated. Our academic differences existed because of a genetic abnormality that occurred in my sister before birth, something that no one, and least of all Lindsay, had any control over. Unfortunately, because her disability is not immediately obvious, Lindsay has also had terrible experiences with employers treating her unjustly, despite her amazing ability to relate to young children and work well in early childhood educational settings. These experiences have had an especially negative impact on Lindsay's self-perceptions. This past year, however, as she has worked with an amazing group of teachers and supervisors at the preschool where she is employed, it has had such a positive impact.

My experiences with my brother and the challenges he faces have largely centered in issues of physical access. The majority of people do not have to worry about finding the one door in a building that is ramped or getting onto the sidewalk if a snowplow deposits a pile of snow on the corner ramps. When I purchase tickets for an event, it is a relatively straight-forward process in which I have multiple choices of where to sit and with whom. When I attend events with my whole family, however, we generally cannot sit together. Usually only one person is allowed to sit with the individual in a wheelchair in the wheelchair accessible sections. Furthermore, these sections are the only place in an auditorium or stadium where someone in a wheelchair can sit.

Michael is passionate about sports. I remember going to his t-ball games when he was really young and watching them figure out how to adjust the ball so he could reach it, and designate a runner, because of the difficulty of negotiating grass in a wheelchair. When Michael was a teenager, my parents discovered programs that sponsored wheelchair basketball, tennis, ice hockey, and skiing. However, each of these programs was offered in an urban area between 30 to 60 minutes away from our home. We would take turns driving Michael to practices and games. Again, because of something that happened before birth and that was not anyone's "fault," things that most families do without thinking or without much inconvenience had to be carefully orchestrated in mine. Thus, it was through my experiences with my siblings where I first learned about discrimination based on differences as well the importance of being responsive to the diverse needs of others.

Another family member who influenced my interests in this area was my grandpa. While I loved and was privileged to grow up near all four of my grandparents, my maternal grandfather played a significant role in how I viewed the world. My grandpa was born in a one-room log cabin, in a small mining town in rural Utah, just before the Great Depression. My grandpa loved learning and language. While he worked in the mines for a short time, he decided he wanted something different for himself and decided to become a teacher. After serving in the Navy during World War II, my grandpa was able to attend college to become an educator with the government assistance provided to some servicemen. After finishing his bachelors degree, my grandpa continued into his graduate education as he taught high school English, eventually graduating with a Ph.D. and becoming an English professor at a large university.

My grandpa's story is the traditional "pull yourself up by the bootstraps" American success story that many people love to tell. However, it is not the story my grandpa told as he shared his story with his grandchildren nor when he wrote his autobiography, *Retrospective*. He had a deep respect for his parents and friends who supported and encouraged his goals as he grew up. He readily acknowledged the privileges he had been granted and the external forces that had allowed him to eventually become a professor. It was never "all about him," and that had a deep impact on me throughout my life.

When one of my uncles was five years old, he refused to get out of the car at a park because there was a child from India playing there. He had never interacted with a person of color before, and he was scared of a child who looked different than him. Following this experience, my grandpa felt he needed to ensure that his children had opportunities to live in a place where they could interact with and learn to value the cultural, ethnic, and racial backgrounds of others. He accepted a position as a visiting professor at a university in Singapore, and moved the whole family there (i.e., my grandparents and their five children). Initially, the family was highly resistant to this change, but it ended up being an amazing experience for them as they had the opportunity to learn about Chinese, Indian, and Malay cultures, among others. They loved their time there, and my cousins and I grew up hearing stories from our parents, aunts, and uncles about their experiences. Over my lifetime, I have gotten to meet many of the friends they made, when these friends visited the US or we visited Singapore.

Whenever I heard my grandpa talk to anyone or about anyone, he was respectful and accepting. Some of my favorite memories are of sitting with him talking about the origins of words, followed by an instructive (and gross) story about what was involved in getting one of the live chickens in the yard ready for his mother to prepare for dinner. He talked as easily about using a pig's bladder to play football (which, incidentally, is why a football is sometimes referred to as a pigskin) as he did about the current history book he was reading. My grandpa has long been someone I have admired and patterned my goals and educational journey after. Though he passed away in 2018, I am so grateful he got to see me start my doctoral journey.

Before beginning my doctoral program full time, I was an elementary school teacher for 16 years: 14 of these years as a third or fourth grade classroom teacher and the final two in a teacher leadership position supporting student teachers, interns, new teachers, and the principal of the school. I loved being a classroom teacher, and I loved supporting other teachers. However, as is becoming increasingly common for mid-career teachers, I left teaching because of the tension I felt between wanting to engage all of my students in learning opportunities that were responsive to and meaningful for them and feeling unable to do so at the level I desired. This disconnect came because of the limits of my own knowledge, time, and resources and because of external constraints, including high-stakes testing, increasing professional responsibilities outside the classroom, and increasing "push back" from administration on practices and curricula I felt were not responsive to my students. I consider myself a type of "principled leaver" (Santoro, 2011), or someone who left teaching because "they [were] being asked to engage in practices that they believe are antithetical to good teaching and harmful to students" (p. 2671).

I enrolled in a doctoral program with the goal of becoming a teacher educator and teacher education researcher. Because of my own experiences as a mid-career K-8 teacher, I wanted to focus my dissertation on supporting other mid-career K-8 teachers through developing PD opportunities that were more responsive to their specific contexts, challenges, and needs. In all my years of teaching, I rarely participated in a PD that I felt was especially impactful in helping me be more responsive to students. My most powerful learning experiences actually came through my master's degree program, which focused on English as a Second Language. Despite carrying this deficit-oriented degree title, I received amazing instruction centered in responsive and equitable teaching practices. I took a multicultural education course that changed how I looked at the world and made me much more aware of my own sociocultural identity, as a White female from a middle class background. My passion for researching and supporting teachers in CRT and addressing issues of equity grew largely out of my experiences during my master's degree.

My doctoral studies, my work in the SEER program, and the tragic events of 2020 have further shaped my desire to actively challenge inequitable practices and policies in education and to support other teachers in doing the same. As a white female doctoral student, I come from a place of privilege. However, I have come to realize how important it is to examine and acknowledge this privilege and how it impacts how I teach and my interactions and relationships with others. I seek to be equitable and antiracist in my interactions with others. I recognize that this is an ongoing process which I am committed to continuing to engage in, in part through this dissertation study, which builds on my own sociocultural, personal, and professional identities and experiences, as detailed in this section.

Statement of the Problem

Researchers of teacher professional learning have often concluded that PD is critical for those who are already classroom teachers (Carter Andrews & Richmond, 2019). PD is also essential to ensuring that teachers have the content and pedagogical knowledge and practices to meet the needs of a culturally diverse student population (Prenger et al., 2017). This includes providing opportunities for teachers to "continually and critically reflect on the ways in which their personal and professional identities inform their (in)ability to effectively meet the needs of a diverse student population" (Carter Andrews & Richmond, 2019, p. 408; see also Matias, 2013).

Despite these assertions and past scholarship, however, teacher identity and a focus on educational equity have largely been left out of the foundational literature on "effective" teacher PD generally (e.g., Darling-Hammond et al., 2017; Desimone, 2011) and in relation to science and engineering PD specifically (e.g., Reimers et al., 2015). This is problematic given the ongoing educational inequities experienced by populations of students who have been underserved and minoritized (e.g., Atwater et al., 2013; Ramsay-Jordan, 2020). CRT is one promising approach to support teachers in disrupting and addressing these inequities (Brown, 2017). However, there is a scarcity of research on PD for science and engineering educators that supports these teachers in developing the knowledge, skills, and dispositions they need in order to enact CRT (Brown & Crippen, 2016; Sleeter, 2012). This is especially true in regards to studies focused on supporting mid-career K-8 teachers in enacting culturally responsive science and engineering instruction.

Mid-career teachers, defined in this study as teachers with between six to 20 years of teaching experience, have generally been the group of teachers least likely to leave the profession (Tye & O'Brien, 2002; Day et al., 2007). Mid-career teacher attrition is increasing (Goldring et al., 2014), however, as these teachers experience increased tensions in their professional and personal identities (Garner & Kaplan, 2019). Therefore, mid-career teachers may particularly benefit from PD experiences focused on helping them to develop or strengthen their identities and actions as culturally responsive teachers.

Mid-career teachers have generally moved beyond the "survival" phase of their early career and are ready to tackle complex challenges (van der Want et al., 2018). Supporting teachers in developing asset-based views of their students' backgrounds and developing strategies to meet the needs of a diverse student population can reduce tensions that often develop in mid-career teachers' identities when they perceive a disconnect between what they would like to do and what they feel is possible within their teaching contexts (Santoro & Morehouse, 2011). Mid-career teachers are in a position to become mentors to other teachers (Day & Gu, 2009), by way of their experience and standing in their teaching contexts, and can therefore have a wide reach in terms of helping others build culturally responsive practices and identities as change agents and student advocates (Segura et al., 2019; Vass, 2017). Thus, helping teachers grow into identities as culturally responsive teachers and advocates of their students' STEM trajectories can yield benefits not only for those teachers, but also for the students, other teachers, the school, and the community in which the school is situated (Edwards et al., 2019).

I chose to focus on mid-career K-8 science and engineering teachers in this study - rather than STEM teachers generally - for three reasons: (1) because of the relatively recent addition of engineering to the science curriculum in most states (e.g. Next Generation Science Standards [NGSS], NGSS Lead States, 2013); (2) the lack of training most K-8 teachers have had in these disciplines (Dresner & Worley, 2006; Goodnough, 2016); and (3) the specific context of the focal PD intervention described later in this chapter.

According to Riegle-Crumb (2011), disparities in students' career aspirations related to STEM fields exist by the time they reach high school. Thus, what happens in science and engineering courses or content in K-8 plays a role in determining who has access to and ultimately works in STEM fields, which have "traditionally been the domain of White males and continue to be stereotyped as such" (p. 459). PD focused on culturally responsive science and engineering teaching could be helpful in shifting these disparities. Engineering education specifically presents opportunities for teachers to implement CRT by connecting students' engineering endeavors to the needs, concerns, and opportunities in their own communities and fostering students' *rightful presence* in STEM (Calabrese Barton & Tan, 2019). Rightful presence is defined as students' "legitimate" membership in a school or classroom community "because of who one is (not who one should be), in which the practices of that community work toward and support restructuring power dynamics toward more just ends through making injustice and social change visible" (Calabrese Barton & Tan, 2019, p. 3).

The Research Experience for Teachers (RET) program is a PD program endorsed by the National Science Foundation (NSF) as a way to broaden the participation of students from underrepresented populations in STEM fields (Krim et al., 2019). The focal RET for this study was part of the Solar Energy Engineering Research (SEER; pseudonym) program. The RET was a five-week summer program, through which local teachers engaged in authentic engineering research related to solar energy and, simultaneously, designed science and engineering curricula for their classrooms. As curriculum design was a required element of program participation, teachers had the opportunity to explore and integrate CRT into the curriculum they created for the following school year. SEER program developers had incorporated culturally responsive practices in their work with middle and high school students participating in the program. Thus, there was evidence that students could gain from such efforts (Wakefield, Jordan, & DeLaRosa, 2018; Jordan et al., 2019). Accordingly, for this dissertation study, I designed a PD intervention to be embedded into the SEER RET program.

Purpose of the Study

The purpose of this study was to design an equity-centered PD intervention that could be integrated with an existing science and engineering teacher PD. Specifically, the Responsive and Empowering Science and Engineering Teachers (RESET) PD program was designed to foster mid-career K-8 teachers' role identities as culturally responsive science and engineering teachers. Further, RESET was designed to support teachers in creating and implementing science and engineering instructional materials that could be adapted to be responsive to their students' diverse intersectionalities. The designed intervention, RESET, was integrated into teachers' curriculum work as participants in the summer RET program. This intervention is explained in detail in Chapter 3.

In design-based research (DBR) studies, researchers aim to develop "humble" (Cobb et al., 2003, p. 9) theories in addition to empirically discovering what works (Barab & Squire, 2004). Therefore, the dual goals of my DBR study were to support teachers in becoming culturally responsive engineering teachers, but also to study if and how that happens. My conjecture was that integrating a focus on the attributes of CRT as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering content, research, and design will influence teachers' curriculum design during the summer program and their enactment of the curricula in the following school year.

Research Questions

This study was guided by two research questions. The first focused on the outcomes of RESET and the second on the design:

1) How does integrating a focus on culturally responsive teaching into a designed PD intervention - through critical discussions of experiences, examples, and pedagogical strategies - influence mid-career K-8 teachers':
    a) Role identity development as culturally responsive science and engineering teachers?
    b) Science and engineering curriculum development, instructional practice and actions as advocates and agents of students' equitable access to and participation in science and engineering?

2) What do we learn about how to integrate a focus on culturally responsive teaching as an inherent part of a science and engineering PD?

Like other design-based research (DBR) studies, I primarily focused this dissertation study on describing the designed PD intervention, the participants' related learning progressions, and the relationship between the intervention and learning progressions (e.g., Boelens et al., 2020; Picower, 2011).

Significance of the Study

Issues of inequity and the underrepresentation of many groups in STEM disciplines and careers continue to exist despite decades of research seeking to build awareness of and help address these issues within educational contexts (e.g., Calabrese Barton & Yang, 2000; Warren et al., 2001). Much of the research on science and engineering PD for K-8 teachers remains focused on teachers' content and pedagogical knowledge and practices (e.g., Pleasants et al., 2020; Utley et al., 2019). While these areas are a critical part of teacher PD and supporting students' access to and participation in science and engineering, developing teachers' ability to be culturally responsive to their students' intersectionalities is also an essential, but often neglected, aspect of teacher PD (Kohli et al, 2015).

K-8 science and engineering instruction is an especially promising context for implementing CRT (Brown, 2017). Engineering focuses on solving problems and "designing objects, processes, and systems to meet human needs and wants" (NRC, 2012, p. 202). Therefore, this discipline benefits from a wide variety of perspectives and can easily be connected to students' communities and funds of knowledge to help students establish a rightful presence in engineering (Calabrese Barton & Tan, 2019; Sias et al., 2016).

The studies that do focus on integrating issues of equity into science and engineering teacher PD often focus on new teachers, or those with five or fewer years of teaching (e.g., Edwards et al., 2019; Rosebery et al., 2016). Few, if any, studies exist examining equity-focused science and engineering PD for mid-career teachers, despite Richter et al.'s (2011) finding that mid-career teachers had the highest uptake of learning from PD training of any teacher group. Just as with students in the classroom, teachers' knowledge, experiences, and needs for support vary greatly not only by individual, but also as groups across the span of their careers. Explaining the need to focus PD efforts on more experienced teachers, Carter Andrews and Richmond (2019) argued:

> Practicing teachers understand the importance of the context in which they are teaching and the opportunities and challenges their students face. New teachers have not experienced these contexts with any longevity, and are more likely to have had brief clinical experiences throughout their teacher preparation program that allow them opportunities to bridge theory and practice.

Mid-career teachers often understand their contexts and their students' opportunities and challenges and the importance of these factors in shaping students' learning. Yet, deficit thinking about students' diverse intersectionalities remain common (Gay, 2018). Through this study, I sought to address the lack of research exploring and explaining science and engineering PD for mid-career K-8 teachers that integrates a focus on CRT as a way to disrupt inequities and teacher learning as part of the identity development process. Specifically, through designing a PD intervention that could be adapted to the teachers' contexts and needs, I investigated how PD could support these teachers in using their understanding of students and contexts to develop asset-based, culturally responsive curriculum, practices, and environments in their classrooms.

Definitions of Key Terms

Many of the concepts central to this study are complex and have been defined in several different ways. Here, I provide the definition of how I conceptualized these terms for this study as provided by the scholars whose work I drew from. Further discussion of these terms is included in the next chapter.

- **Advocates:** Teachers who are "not only aware of promises and restraints of the educational system, but they are active in creating spaces where the diverse needs of students who have been marginalized are met at both the classroom and school levels" (Bradley-Levine, 2018, p. 50).
- **Change Agents**: Teachers who "work purposefully with others to challenge the status quo and develop social justice and inclusion" (Pantić & Florian, 2015, p. 333).
- **Culturally Responsive Teaching**: "Using the cultural knowledge, prior experiences, frame of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (Gay, 2010, p. 31)
- **Culture:** "values, attitudes, and beliefs; customs and traditions; heritages and contributions, or experiences and perspectives" of an individual or group (Gay, 2013, p. 54)

- **Equity in Education**: "Provid[ing] students, regardless of their racial, ethnic, cultural, or gender background with what they need to succeed - not some predetermined practices that may or may not be appropriate" (Milner, 2011, p. 64)
- **Identity:** "teachers' overall conception of who they are as teachers, who they believe they are, and who they want to be as teachers" (Beijaard, 2019, p. 1)
- **Intersectionality:** "categories such as gender, race, class, ability, and other aspects of identity" that "interrelate on multiple, and often simultaneous dimensions, contributing to systemic social inequality" (Boveda, 2016, p. 20).
- **Social Justice Teaching:** "An ongoing struggle for more caring, equitable, and agentic schooling at classroom (micro), school (meso), and community/society (macro) levels" (Rivera Maulucci, 2013, p. 454)

Dissertation Overview

The dissertation is organized into five chapters. The first chapter provides background information about the researcher and the purpose and significance of the study. The second chapter summarizes literature relevant to the study and related to four key topics: (1) teacher PD; (2) teacher identities, including an overview of the theoretical framework and key role identities explored through this study; (3) CRT, including the background, attributes, and implications of this pedagogical approach; and (4) DBR, including an overview of this methodological approach, common critiques, and a summary of related DBR studies. The third chapter describes the research methods used in this study. It includes a detailed description of the context, participants, and data collection and analysis procedures. It also includes an in depth description of how the first iteration of the RESET PD intervention was designed and implemented.

In the fourth chapter, findings related to RQ 1 are presented and discussed. Specifically, findings from case studies of the four focal teachers are presented and themes across the four cases are discussed. The final chapter contains the findings and discussion related to RQ 2. This includes the findings related to if and to what extent the conjectures, processes, and outcomes of RESET were achieved. These findings lead to a discussion of the implications for the second iteration of RESET, referred to as RESET 2.0, as well as for the general scholarship related to the topics of interest in this study. Chapter 5 ends with a conclusion to the dissertation study.

CHAPTER 2

LITERATURE REVIEW

This dissertation study was primarily grounded in and guided by the literature in three areas: teacher PD, teachers' identities, and CRT. Additionally, because of the lack of naturalistic models of PD that centralize mid-career teacher identities as culturally responsive science and engineering teachers, I chose to conduct a DBR study. This chapter is organized into four sections. First, I provide an overview of the literature related to teacher PD, as that is the context of the designed intervention. Then, in the following sections, I focus on literature about two key concepts and related frameworks integral to RESET: teacher identity and CRT. Finally, I detail DBR as my chosen methodological approach for integrating CRT and teacher identity into the RESET PD intervention.

Professional Development

Teacher PD, broadly defined, is "any program, activity, or training aimed at improving instructional practice" (Osman & Warner, 2020, p. 1). Accordingly, PD can occur through formal activities, such as structured training or workshops, or informal activities, such as conversations with other teachers (Desimone, 2011). The primary goal of PD is to foster positive change in schools, teachers, and student learning (Opfer & Pedder, 2011). Within educational contexts it is "widely accepted" that PD fosters improved teaching, though there is mixed evidence in the body of research in terms of whether or not this is true (Kennedy, 2016, p. 945; Osman & Warner, 2020). Here, I briefly review the literature about what makes teacher PD "effective" generally and as related to science and engineering PD. I then describe the limitations of this literature in terms of designing a PD that supports teachers in taking up practices and identities associated with becoming culturally responsive science and engineering teachers.

Key Features of Effective Professional Development

Darling-Hammond and colleagues (2017) defined "effective" PD as "structured professional learning that results in changes in teacher practices and improvements in student learning outcomes" (p. 2). In their review of 35 empirical studies that linked PD with positive changes in teacher practice and student learning, Darling-Hammond and colleagues identified seven key features. They explained that effective PD is *content focused*, incorporates *active learning*, supports *collaboration*, uses *models of effective practice*, provides *coaching and expert support*, offers *feedback and reflection*, and is of *sustained duration* (see Table 1).

Table 1

Seven Features of Effective PD

Effective PD	Participating Teachers…
Content focused	● Focus on specific content and related teaching strategies ● Develop discipline-specific curriculum
Active learning	● Experience and design the same teaching and learning strategies, authentic artifacts, and activities they (will) use with their students
Collaboration	● Share ideas and collaborate in their learning ● Create communities that positively change culture and instruction
Models of effective practice	● Engage with models that clearly show best practices (e.g., lesson plans, unit plans, sample student work, peer observations, videos)
Coaching and expert support	● Share and receive content expertise and evidence-based practices focused on their individual needs
Feedback and reflection	● Have built-in time to think about, receive input and feedback on, and make changes to their practice
Sustained duration	● Participate beyond a single workshop or PD session

Note. All explanations summarized from Darling-Hammond et al., 2017, p. v-vi

These seven features provide a framework that embodies much of the past seminal work in this area (e.g., Desimone, 2011; Garet et al., 2001; Guskey & Yoon, 2009; Penuel et al., 2007; Timperley, 2008). Considered together, these seven features emphasize the importance of PD not only introducing teachers to evidence-based teaching practices and content but also remaining highly connected to the specific contexts and needs of teachers and their students. Other research studies also emphasize the importance of coherence between the PD model and several factors, including teachers' knowledge and beliefs (Desimone, 2011), teachers' goals for their own and their students' learning (Penuel et al., 2007), and state standards and assessments (Garet et al., 2001). These factors highlight the wide range of affective and contextual impacts on PD's effectiveness.

Through the selection of these seven features of effective PD, Darling-Hammond and colleagues' (2017) also focused on giving teachers adequate time, support, and feedback to reflect on, practice, and learn discipline-specific content and pedagogical skills in collaboration with others. From their analysis of empirical studies of PD, Guskey and Yoon (2009) found that effective PD models included 30 or more contact hours with participants. However, they cautioned that the time teachers spend in PD activities "must be well organized, carefully structured, purposefully directed, and focused on content or pedagogy or both," as "doing ineffective things longer does not make them any better" (p. 497). However, when teachers participated in PD that allowed for teachers' active engagement in learning with support over longer periods of time, teacher learning and changes in practice that positively impacted student learning were increased (Desimone, 2011).

Another feature of effective PD noted by Darling-Hammond et al. (2017) was supporting collaboration. Existing research has focused almost exclusively on PD contexts in which teachers have opportunities to collaborate solely with other teachers, especially teachers from the same grade levels, schools, and districts (e.g., Desimone, 2011; Garet et al., 2001; Penuel et al., 2007). Based on empirical findings, these researchers argue that having groups of teachers within the same grades and schools participate in PD together provides opportunities to develop and strengthen professional learning communities, facilitate implementation of interventions and school change, and increase student achievement.

Conversely, Darling-Hammond and McLaughlin (2011) argued that "a powerful form of teacher learning comes from belonging to professional communities that extend beyond classrooms and school buildings" (p. 84). Further, Timperley (2008) and Guskey and Yoon (2009) emphasized the importance of including "experts" in PD to facilitate and provide support for new content, skills, and practices. Guskey and Yoon argued that experts should come from outside the school (e.g., researchers or program authors) to directly train teachers on how to integrate theory-based practices or curricular programs into their instruction. While these researchers also focused specifically on PD with just communities of teachers, or those closely connected to education, they highlighted the importance of diverse perspectives in the process of learning and change.

Science and Engineering Professional Development

With the integration of engineering content, standards, and practices into K-12 science standards (National Research Council [NRC], 2012; Next Generation Science Standards [NGSS] Lead States, 2013), there has been growing emphasis on science and engineering PD for K-12 teachers. Literature on PD in science and engineering often focuses on three of Darling-Hammond et al.'s (2017) features of effective PD: *content focused*, *models effective practice*, and *active engagement*. Recently, the American Society of Engineering Education adopted five standards for engineering teacher PD (Reimers et al., 2015), largely targeting the features of *content focus* and *models of effective practice*. These standards include helping teachers increase their engineering content and pedagogical knowledge, using engineering as a context to teach other STEM content, and selecting or creating appropriate curricula materials to align with educational research and learning standards. Cunningham and Carlsen (2014) also concluded that engineering PD should help teachers understand engineering as a social as well as technical practice.

Engineering PD programs often include teachers' *active engagement* in a series of workshops designed to strengthen teachers' knowledge, beliefs, and practices (e.g., Guzey et al., 2014; Tuttle et al. 2016; Yoon et al., 2014). In addition, Sun and Strobel (2014) emphasized the importance of teachers not only leaving PD knowing what to do (i.e., content to discuss, activities to implement), but also knowing how to implement their new learning and practices into their specific classroom context. Accordingly, "teachers themselves need to actively engage in the practices of science," in order to be able to implement these practices in their classrooms with their students (Southerland et al., 2016, p. 2). As few teachers have the opportunity to gain this type of experience in their teacher education programs, they need PD that includes opportunities for authentic science and engineering research and design.

In their overview of engineering PD models, Katehi et al. (2009) noted the importance of affective outcomes in addition to knowledge outcomes. They stated that effective engineering PD for younger grades should target three main goals. First, as mentioned in several other studies, it should increase teachers' content, curricular, and pedagogical knowledge. Second, it should help teachers develop confidence in teaching engineering. Third, it should increase teachers' positive attitudes towards engineering. All three of these goals target important aspects of teachers' science and engineering teacher identities and should be a key part of any science and engineering PD models.

The Research Experience for Teachers

The National Science Foundation (NSF, 2017) supports research apprenticeships such as the Research Experience for Teachers (RET) as one viable science and engineering PD model. RET programs, such as those funded by NSF, are designed to help teachers gain knowledge and research experience from scientists and engineers and implement the same types of practices with the K-12 students in their classrooms using curricula they have developed (e.g., Miranda & Damico, 2013; Pop et al., 2010). In RET programs, teachers apprentice to science or engineering researchers and participate in an authentic research project focused on a specific topic.

Participating in an RET program full-time over a minimum of five consecutive weeks during the summer, teachers build science and engineering content knowledge, as well as research skills and practices. Additionally, NSF expects teachers participating in RET programs to develop curricula materials related to the apprenticeship, integrating their new scientific and engineering knowledge into classroom activities. However, NSF (2017) provides little direction on how to ensure that the teachers' research experiences transfer into the curricula materials they create, nor does it provide explicit guidance for how program directors can develop teachers' capacity to design instruction incorporating practices that are potentially new to them. These design decisions and modes of support are left to the directors, designers, and facilitators of each RET.

Missing Features in the Scholarship of PD

Across the literature on PD generally and science and engineering PD specifically, I argue that there are two key characteristics of effective PD that are often lacking from the seminal scholarship. First, teachers come to PD programs with diverse professional backgrounds and experiences (Darling-Hammond & McLaughlin, 2011). Thus, teachers' responses to the same PD often vary considerably (Desimone & Garet, 2015). PD models should purposefully build on teachers' identities, or who they are (Beijaard & Meijer, 2017). PD should also foster teachers' agentive actions related to the PD (Garner & Kaplan, 2019; Priestley et al., 2015) and meaningfully connect the goals of the PD to teachers' professional goals, or who they want to become as teachers (Beijaard, 2019).

The second missing feature is an explicit focus on issues of social justice and equity in education integrated into all types of PD, regardless of the content area or other objectives. Teachers need to learn to be more responsive to their students' intersectionalities, to advocate for their students and to provide space for students to advocate for themselves, and to actively work to disrupt ongoing discriminatory practices and inequities in education. In a PD model, according to Kohli et al. (2015), this focus should engage teachers as politically-aware educational stakeholders who are working toward social transformation as well as professional growth.

Recently, there has been increased focus in the PD literature on both identity and equity (e.g., Carter Andrews & Richmond, 2019; Edwards et al., 2019; Noonan, 2019). Specific to STEM, Wright et al. (2018) argued that meaningful PD should support STEM teachers in four ways. It should help them to 1) meet the varying needs of their "linguistically, economically, socially, and culturally" diverse students; 2) gain content knowledge related to "continually updated academic standards;" 3) value inclusion through a social justice focus and culturally sustaining pedagogies that encourage and enable students to persevere in science, technology, engineering, and math (STEM) fields; and 4) engage in their local communities to "feel connected to the place where they live and work" (p. 12). Despite this increase, though, there are still few empirical studies in this area, especially as related to mid-career K-8 science and engineering teachers. Therefore, in designing the RESET PD, I sought to centralize both of these "missing" features of PD: teacher identity and CRT.

Teacher Identity

Teacher identity "stands at the core of the teaching profession. It provides a framework for teachers to construct their own ideas of 'how to be', 'how to act' and 'how to understand' their work and their place in society" (Sachs, 2005, p. 15). Like the concept of identity generally, researchers from a variety of fields have struggled to define teacher identity (Beijaard et al., 2004). Beauchamp and Thomas (2009) posited that this difficulty stems from the complexity of identity, as researchers must try to understand the connections and relations between identity and self, emotion, agency, and contexts. Further, researchers seek to understand how each of these connections shape identity and how stories, discourse, and reflection lead to understanding identity.

The scholarship of teacher identity has used varying definitions, often centered on common key dimensions such as its complex, dynamic, sociocultural nature, identity-self and identity-agency connections, and narratives as tools for developing and making sense of identity. Researchers have sought to capture these dimensions through holistic teacher identity questions such as “who am I as a teacher?” and “who do I want to become?” (Beijaard et al. 2004; Kelchtermans & Hamilton, 2004). For the purposes of this proposal, I center my discussion around “teachers’ overall conception of who they are as teachers, who they believe they are, and who they want to be as teachers” (Beijaard, 2019, p. 1). I first briefly review the literature on teacher identity, outlining how teacher identity has been discussed in the education research generally, particularly in regards to key aspects of and tensions surrounding teacher identity. I then discuss teacher identity in relation to issues of relevance to my planned dissertation study, specifically examining special issues of concern for mid-career teachers’ identity, how the literature defines STEM teacher identity and how it addresses issues of teachers’ identity as advocates of social justice and equity.

Key Aspects of Teacher Identity

Teacher identity researchers often discuss who teachers are and who they believe they are in conjunction with “self,” or self-concept (Beauchamp & Thomas, 2009). In explaining the relationship between self and identity as it pertains to teachers, Rodgers and Scott (2008) explained that self could be “thought of as the meaning maker and identity as the meaning made, even as the self and identity evolve and transform over time” (p. 739). In other words, teachers use who they believe they are (self-concept), to determine who they are (identity). In their discussion of identity and self, Lauriala and

Kukkonen (2005) identified three interacting dimensions of the self: the actual self (who teachers currently are), the ought self (who society or an external group says teachers should be), and the ideal self (who teachers' want to be).

Building on the research of identity and self, teacher identity scholars generally agree that teacher identity is complex, dynamic, and contextually defined and shaped. Danielewicz (2001) commented on the complexity and dynamic nature of teachers' identities, stating that each person "is composed of multiple, often conflicting, identities, which exist in volatile states of construction or reconstruction, reformation or erosion, addition or expansion" (p. 10). Similarly, Beijaard and colleagues (2004) explained that teachers' identities consist of multiple sub-identities, which are generally context-specific or relationship-specific (e.g., science teacher, mentor, department head, family member).

Olsen (2008) viewed identity as a label "for the collection of influences and effects from immediate contexts, prior constructs of self, social positioning, and meaning systems (each itself a fluid influence and all together an ever-changing construct)" (p. 139). In other words, teachers' "identities are a shifting amalgam of personal biography, culture, social influence, and institutional values which may change according to a teacher's role or circumstance" (Day et al., 2006, p. 613). The intertwined influences and effects of these identities, as well as the meaning made of experiences through those identities, shape how teachers react to and negotiate their immediate contexts and relationships (Beauchamp & Thomas, 2009; Sachs, 2005).

Therefore, teachers need a way to make sense of their "shifting, multiple, constructed, contradictory, confusing" identities (Rodgers & Scott, 2008, p. 736). The most widely accepted way of making sense of identity is through narrative discourse or "telling stories" (Connelly & Clandinin 1999; Cohen, 2010; Rodgers & Scott, 2008). Sfard and Prusak (2005) discussed two types of narratives. Teachers narrate their *actual identities* by telling about their current (perceived) realities. They narrate their *designated identities* as something expected either now or in the future. Therefore, actual and designated identities align with the conception of identity as who teachers are and who they want to be.

Under the three broad dimensions of identity (i.e., complex, dynamic, context-specific), teacher identity researchers focus mainly on the interplay of two sets of factors—personal and professional identities as well as internal and external factors—in shaping who teachers believe they are and who they want to be, as told through their narratives (Beauchamp & Thomas, 2009; Beijaard et al., 2004). Like most aspects of teacher identity, it is difficult to clearly define a dividing line between teachers' personal and professional identities (Woods & Jeffrey, 2002). Beijaard and Meijer (2017) explained that teacher identity is both personal and professional in that teachers' personal beliefs about learning and other aspects of schooling determine who they want to become as a teacher, but that those beliefs can shift through interactions with others in a variety of contexts.

Thus, the impact of these contextual interactions emphasize the central role of internal and external factors in teacher identity. As Palmer (1998) explained: "Identity is a moving intersection of the inner and outer forces that make me who I am" (p. 13). Rodgers and Scott (2008) identified contexts and relationships as the main external aspects of teachers' identity development and stories and emotions as the internal, meaning-making aspects. A major focus of teacher identity research is the alignment of the personal and professional identities and how internal and external forces impact this alignment (e.g., Alsup, 2006; Beijaard & Meijer, 2017; Cohen, 2010; Day et al., 2006).

Another key aspect of teacher identity is agency. Priestley et al. (2015) explained that agency "is not something that people can have; it is something that people do or, more precisely, something they achieve" as they engage in actions across time, relationships, and contexts (p. 3). Accordingly, teachers' identities within specific contexts may directly relate to how much agency they perceive or achieve (Beauchamp & Thomas, 2009). A strong sense of identity and agency within educational contexts empowers teachers to create, to act on ideas, to accomplish goals, or even to positively transform these contexts (Parkinson, 2008).

Tensions in Teacher Identity

Tensions or disconnects are common within teacher identities or between teachers' identities and external challenges or expectations (Day et al., 2006; Garner & Kaplan, 2019). Most commonly, these tensions center on differences between what teachers' believe about teaching and learning and what those outside the profession believe or impose (Beijaard & Meijer, 2017). These tensions include teachers' changing roles, desired and actual support of teachers and students, conflicting conceptions of learning, and the work-life balance. Often, teachers experience these tensions as a sense of discontinuity in their identities (van Rijswijk et al., 2016). When balanced with feelings of continuity, these tensions and sense of discontinuity can be productive and lead to learning, change, and growth in teachers' identities (Beijaard & Meijer, 2017).

However, too much tension and discontinuity can lead to identity crises (Woods & Jeffrey, 2002), feelings of failure (Beijaard & Meijer, 2017; Winograd, 2003; Santoro, 2011); and ultimately the “moral distance” that exists when “teachers feel their purposes are being threatened or have been lost” (Hargreaves, 2001, p. 1067). When this moral distance occurs, it can result in “fracturing” or “realignment” of teachers' identities (Hargreaves, 2001; Lindqvist & Nordänger, 2016; Woods & Jeffrey, 2002) or in “principled leaving” (Santoro & Morehouse, 2011).

In an educational climate of high-stakes accountability and performativity agendas, external expectations of what teachers’ identities *should* be often directly conflict with who teachers *are* or *want* to be (Rodgers & Scott, 2008). These expectations include uncritical compliance with educational reforms, reduced time to connect with and address the needs of individual students, and a constrained or threatened sense of agency (Britzman, 1993; Day & Gu, 2007). For example, teachers who desire to work for more equitable and just conditions for students often “find themselves complicit in a system in which they are forced to reproduce the very inequalities they went into teaching to ameliorate” (Picower, 2011, p. 1106). When first faced with these conflicts, teachers often try to negotiate ways to continue supporting their students and teaching according to their beliefs (Santoro & Morehouse, 2011). Over time, though, or with increased conflict, teachers’ identities may “fracture” (Hargreaves, 2001). Woods and Jeffrey (2002) explained fractured identities as teachers’ realignment of their professional identities with external expectations by attempting to separate who they are as a teacher from their assigned teaching role. In short, teaching becomes just a job.

Eventually, “just as principles may motivate teachers to enter the profession, principles may provide justification for leaving, even for teachers who envisioned themselves as committed, long-term educators” (Santoro and Morehouse, 2011, p. 2671).

Issues of moral distance, fractured identities, and principled leaving are often studied with groups of mid-career or veteran teachers as their teacher identities tend to be more established (e.g., Day & Gu, 2009; Santoro & Morehouse, 2011; Woods & Jeffrey, 2002). According to Beijaard et al. (2004) the more central an identity is, the more difficult it can be for teachers to change or lose that identity. Also, as mentioned earlier, difficult teacher identity work is not inherently negative or positive, and it is a key part of learning and growth. However, when this work becomes damaging to teachers (and therefore students) because of extreme tensions and discontinuity, "it should command attention" (Santoro & Morehouse, 2011, p. 2671).

The Dynamic Systems Model of Role Identity

To account for the multiple complexities of teachers' (and others') identities, Kaplan and Garner (2017) developed the Dynamic Systems Model of Role Identity (DSMRI). DSMRI "provides a metatheoretical framework of conceptual principles of the identity system that aim to capture the holistic and rich content, structure, and process of identity and its formation within social-cultural contexts, with anchors in established theoretical constructs" (Kaplan & Garner, 2017, p. 2040). DSMRI consists of a network of four interdependent components central to an individual's identity and action in a specific role: 1) self-perceptions and self-definitions; 2) assumptions and beliefs; 3) purposes and goals; and 4) perceived action possibilities. Table 2 includes the definitions adapted from Kaplan and Garner's (2017) explanation of each of the four components of DSMRI and the emotions and actions related to these components.

Table 2

The DSMRI Component Definitions

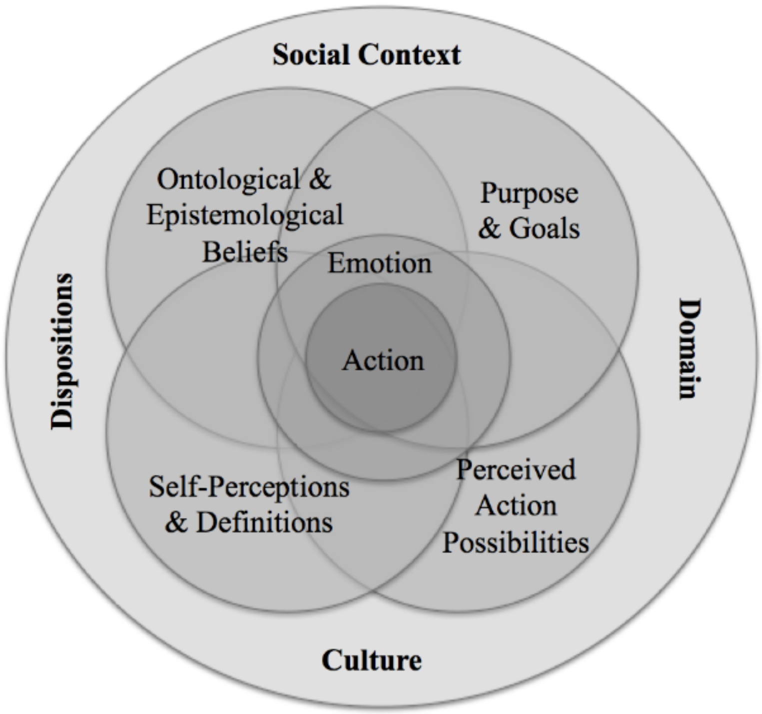
Component	Definition
Ontological and Epistemological Beliefs	Knowledge relevant to the role which the actor holds as true (ontological) and the actor's assumptions about "the certainty, complexity, and credibility of sources of their knowledge" (epistemological)
Purpose and Goals	The actor's overall purpose, concrete goals, objectives, and aims in the role
Self-Perceptions and Definitions	Personal and social attributes/characteristics the actor considers relevant to the role
Perceived Action Possibilities	Behaviors the actor perceives as available to them in the role, especially in terms of moving forward purpose and goals
Emotions	The actor's emotions as related to each of the other components
Action	A behavior the actor engages in and its meaning to the actor

Note. Definitions adapted from Kaplan & Garner, 2017, p. 2040-2041

Kaplan and Garner (2017) created a model to illustrate an individual's role identity (e.g. mid-career teacher, culturally responsive teacher) is a highly complex and interconnected set of both internal action-oriented constructs and external domains and contexts that are continually shaping and being shaped by each other (see Figure 1). As depicted in the model, role identity systems form in domain-specific, sociocultural contexts, and that both cultural meanings and actors' dispositions mediate the systems' components and relationships. This model aligns with the seminal scholarship on teacher identity which emphasized the continually changing and complex nature of identity (e.g., Beijaard et al., 2004; Danielewicz, 2001) and the influence of both internal and external factors on identity (e.g., Day et al. 2006, Olsen, 2008).

Figure 1

The Dynamic Systems Model of Role Identity



Note. From "A Complex Dynamic Systems Perspective on Identity and its Development: The Dynamic Systems Model of Role Identity," by A. Kaplan and J. K. Garner, 2017, *Developmental Psychology, 53*(11), p. 2041 (http://dx.doi.org/10.1037/dev0000339). Copyright 2017 by the American Psychological Association. Reprinted with permission.

DSMRI depicts identity development as an ongoing, nonlinear process "that involves restructuring of the strength and relationships among role identities over time and across context" (Hilpert & Marchand, 2018, p. 188). Accordingly, I chose to use DSMRI as a theoretical framework for my study, which focuses on the relationship between three overlapping teacher role identities (i.e., mid-career, science and engineering, and culturally responsive). Through designing a PD intervention, I sought to support teachers in strengthening their role identities as culturally responsive science and engineering teachers, advocates, and change agents.

Kaplan and Garner (2017) explained that any intervention (e.g. RESET) in a dynamic system, such as identity, is just one of many factors influencing the system at any time and cannot completely determine how the system will change. However, taking into consideration the various components of DSMRI in relation to enacting the targeted role (e.g., culturally responsive science and engineering teaching in K-8), could increase the intervention designers' confidence about how the intervention could influence the actors. For instance, to create a CRT and identity-focused science and engineering PD for mid-career K-8 teachers, designers would initially rely on what they already know about the contexts and general identities of mid-career K-8 teachers in combination with their knowledge effective teacher PD, science and engineering PD, and CRT. The designers could then develop a PD program that could be adapted to the individual identities of the participants to support the teachers in developing or strengthening the "target" role identity of a culturally responsive science and engineering teacher.

Garner and Kaplan (2019), in a case study of a teacher's experience in PD, explained teacher learning in PD in relation to DSMRI:

> The model depicts teacher learning as going beyond change in pedagogical knowledge and skills to encompass change in a network of components that constitute the teacher's identity system, such as the teacher's purpose and goals in teaching, self-perceived attributes regarding teaching, world view as a teacher, and perceived possibilities for action as a teacher. (p. 3)

In order for PD to result in teacher learning and long-lasting change, therefore, it must not only focus on teachers' pedagogical practices. Teachers' actions following PD will still likely be based primarily on that teacher's purposes and goals, beliefs, self-perceptions, and what the teacher perceives as possible. Thus, Garner and Kaplan (2019) argued that PD should result in changes in teachers' role identity systems.

As discussed previously, tensions in teachers' identities can lead to learning and growth or to disillusionment (Beijaard & Meijer, 2017). Garner and Kaplan (2019) discuss these tensions as existing both within and between different role identities. They explained that when different role identities are in tension, teachers often "experience negative emotions, professional dilemmas, and diminished motivation" (p. 6). However, when teachers are able to integrate important role identities, both personal and professional, and find alignment in the components of these identities, the teachers generally "experience personal coherence, high commitment and motivation in the roles, and overall well-being" (p. 6). Accordingly, PD aimed at fostering teachers' role identity formation should introduce new content through a variety of interactions and scaffold targeted changes in ways that intentionally engage teachers in finding connections and alignments between components of their role identities and the new content.

In the next subsection, I focus on three specific teacher role identities central to this study: mid-career teachers, STEM teachers (and specifically science and engineering teachers), and teachers as advocates of and change agents for equitable educational practices. I posit that common tensions in or impositions on these identities should command attention and be further addressed in research and action. Therefore, I overview and discuss how each of these identities has been defined and characterized in previous scholarship. In doing this, I recognize that teachers' identities vary greatly due to complex interactions between multiple factors, as discussed in previous sections. Therefore, my purpose is not to argue that these portrayals are accurate and representative of all teachers with that role identity. Instead, I seek to identify possible commonalities and tensions related to each as a starting place in designing professional development that fosters mid-career K-8 teachers' role identities as culturally responsive science and engineering teachers.

Role Identity: Mid-Career Teacher

Research on mid-career teachers generally has focused on teachers who have anywhere between six to 20 years of teaching experience. This range reflects those who have "made it" through the first five years of teaching, when attrition is the highest (Ingersoll & Merrill, 2013) and those who are not yet actively seeking retirement (Coulter & Lester, 2011). Not all researchers specifically quantify their use of the term *mid-career* (e.g., Woods & Jeffrey, 2002), and others use alternate terms such as *established* or *experienced* to describe these teachers (e.g., Levine, 2013; Day & Gu, 2009). Huberman (1989) chose to represent the mid-career years of teaching through multiple stages. For the purposes of this study, I used the term *mid-career* to refer to teachers with between six and 20 years of classroom teaching experience.

Characteristics of Mid-career Teachers' Identities

From his study of teachers' professional life cycles, Huberman (1989) described the experimentation/activism stage of teachers who had been teaching approximately seven to 18 years. In this stage, teachers often felt ready for new challenges and opportunities, worked to increase the impact of their instruction, and challenged institutional barriers. They often held additional positions of responsibility within the school and mentored new and preservice teachers (Day & Gu, 2009; Margolis, 2008). These extra responsibilities could sometimes assuage mid-career teachers' goals to take on new challenges, but could also place additional demands on their time and resources (van der Want et al., 2018). Historically, mid-career teachers have been the most stable population of educators in terms of attrition, expertise, and professional identity (Tye & O'Brien, 2002; Day et al., 2007). However, mid-career teacher attrition has been increasing (Goldring et al., 2014), largely due to identity tensions.

Common Tensions in Mid-career Teachers' Identities

The research on mid-career teachers has focused on three main tensions. First, as discussed previously, researchers found that mid-career teachers were especially susceptible to teacher identity crises. Woods and Jeffrey (2002), who studied the impact of new reform and performativity measures on mid-career and veteran teachers' identities, explained that "for the mid-career teachers…a unified self-identity had been unchallenged for many years. It was deep in the heart, but not in the forefront of their minds," and new imposed standards, practices, and evaluations "forced them to reconsider and reconstruct" (p. 104) their perceived action possibilities and actual actions and practices. The ensuing focus on accountability often led teachers to blame themselves for failure without acknowledging the oppressive contextual conditions as a contributing factor (Santoro, 2011). This was unfortunate because teachers' contexts and the culture of those contexts could have a significant impact on teachers' self-perceptions of their role identities as teachers and their feelings of success within the profession (Beijaard et al., 2004).

A second frequent tension for mid-career teachers was the lack of learning opportunities specific to their needs or that fostered and supported their professional identities (Day & Gu, 2007). According to Leitch (2010), PD focused on teachers' identities and the dynamics between person, professional, and political could help mid-career teachers to reshape what was possible. Ideally, mid-career teachers' learning would be self-selected and self-directed, increase their knowledge of content and teaching practices, enhance their self-perceptions and efficacy, introduce new action possibilities, and focus on teachers' specific learning goals (Day & Gu, 2007; Garner & Kaplan, 2019). In short, their learning would center on who they were as teachers and target who they wanted to be. However, realistically, teachers' working conditions often do not promote learning and growth (Day & Gu, 2007).

Finally, mid-career teachers experienced tensions when they were asked to play multiple roles within the school or district (Day & Gu, 2009). Depending on the context and sociocultural factors, this could be a positive tension with opportunities for new growth, learning, and change (Margolis, 2008) or a negative tension when accompanied by high expectations but low support (Santoro, 2011). Additionally, mid-career teachers experiencing this negative tension often reported issues balancing their personal and professional roles as well as their teaching and other responsibilities (Sammons et al., 2007; van der Want et al., 2018).

Mid-career teachers' decisions (e.g., cutting back, leaving the profession, going back to school), made in response to these tensions and crises, are generally deeply tied to their identities (Lindqvist & Nordänger, 2016). While not all attrition from the teaching profession is negative, it can be costly to lose – either physically or emotionally

– a highly qualified, experienced and skilled teacher (Santoro & Morehouse, 2011). When this happens, the whole school community (e.g., students, prospective and new teachers, administration) can feel the impact (Santoro, 2011). Thus, if mid-career teachers are feeling powerless to change their circumstances, developing an identity as an advocate for themselves and their students could be empowering and perhaps promote longevity in teaching.

Role Identity: Science and Engineering Teacher

While an extensive body of research exists around STEM teaching and learning as individual content areas, over the past two decades, there has been growing interest in integrated approaches in K-12 education (Honey et al., 2014; Williams, 2011). Accordingly, STEM education has evolved into "a meta-discipline," removing divides between the STEM disciplines and focusing on the process of designing innovations to solve complex problems using available technologies and other resources (Kennedy & Odell 2014, p. 246). Advocates of integrated approaches to STEM posit that connecting the disciplines through authentic problem solving contexts makes the content more relevant to both students and teachers and increases student motivation, interest, achievement, and persistence in STEM through and beyond their K-12 schooling (Roberts, 2013; Stohlmann et al., 2012).

Though "developing a STEM identity" is often mentioned as a goal for both students and teachers, Honey et al. (2014) noted a lack of studies on STEM identities. Research on teachers' STEM identity is especially scarce and generally focuses on externally-defined "ideal" aspects of these identities (e.g., Honey et al., 2014; NRC, 2010, 2012; Wang et al., 2011). As a notable exception, El Nagdi and colleagues (2018) interviewed STEM teachers to determine their internal perspectives on the critical elements of their STEM identities.

Characteristics of a Science and Engineering (and STEM) Teachers' Identities

The STEM teacher literature has often focused on specific roles of STEM teachers, such as finding or designing curriculum and implementing it, connecting "real world" and classroom practices, and focusing on innovation and application (El Nagdi et al., 2018). Additionally, Wang et al. (2011) explained that teachers' STEM identity targeted three key purposes: 1) deepening students' knowledge and understanding of each discipline; 2) exposing students to socially and culturally relevant STEM contexts to broaden their STEM understanding; and 3) increasing pathways into STEM fields through fostering students' interest in these disciplines throughout their K-12 years. In order to accomplish these purposes, teachers needed to have enough content knowledge and pedagogical content knowledge in all four disciplines to execute this integration (Honey et al., 2014; Roehrig et al., 2012).

The teachers interviewed in El Nagdi and colleagues' (2018) study shared narratives of their STEM identities. While the teachers found that these targeted purposes of a STEM teacher role identity aligned well with their overall teacher identities, actually enacting this multifaceted role identity was an ongoing process. The teachers also reported their beliefs that the critical components of their STEM teacher identities included an openness to contextual changes and to being a change agent, understanding STEM content and practices, a focus on equity and inclusion, and awareness of social issues and community needs. Though this study only included a small number of teachers' perceptions, collected through interviews, it was a place to start in thinking about STEM teachers' identities.

Because the context of my study specifically targeted teachers' growth as science and engineering instructors, I briefly address these sub-identities of teachers' overall STEM identity. Engineering, generally considered a post-secondary school subject, became focal in K-12 schools only within the past decade (Cunningham, 2009). It expanded into the early years of schooling due to the growing emphasis in the US on students' achievement in STEM subjects. In 2012, the NRC released the *Framework for K-12 Science Education* to guide the creation of new science and engineering standards. This framework focused on three dimensions: 1) core ideas from the disciplines of science, engineering, and technology; 2) cross-cutting concepts from science and engineering's "common application across fields;" and 3) authentic scientific and engineering practices (NRC, 2012, p. 2). The Next Generation Science Standards (NGSS Lead States, 2013), and similar K-12 state standards implemented across the US, generally adopted the NRC's framework.

In the report *Preparing Teachers,* the NRC (2010) emphasized key knowledge, skills, and dispositions central to science and engineering teachers' identities. Teachers needed to develop their own understanding of science and engineering practices (e.g., modeling, argumentation), cross-cutting concepts (e.g., patterns, systems), and disciplinary core ideas (e.g. life sciences) as outlined in NGSS and based on the framework (NRC, 2012). Additionally, teachers needed to develop their pedagogical content knowledge and instructional strategies specific to teaching science and engineering (Cunningham & Carlsen, 2014). This included a focus on teachers not only knowing relevant content and practices, but also fostering this knowledge and practices in their students in meaningful ways (Sun & Strobel, 2014). Ideally, science and engineering teachers understood, believed in the importance of, and had perceived action possibilities for building on students' background knowledge and supporting students' understanding of science and engineering (Calabrese Barton & Tan, 2009; Wilson-Lopez et al., 2016).

Common Tensions in Science and Engineering (and STEM) Teachers' Identities

The research on existing tensions in science and engineering teachers' identities has centered on four main areas: 1) the need for teachers to gain STEM content knowledge and pedagogical strategies; 2) the disconnect between teachers' perceptions and beliefs about what should or could be enacted in a science and engineering classroom and the complexities of "real-world" science and engineering practice; 3) teachers' past (often negative) experiences with STEM content; and 4) unrealistic external expectations. According to Williams (2011), STEM teachers needed to understand how to effectively integrate all or some of the STEM disciplines. For example, the addition of engineering content to the K-12 science curriculum created a need for quality engineering professional development. This was especially true for elementary and middle school teachers, who may not have had opportunities to develop in-depth content knowledge in any of the STEM content areas, and who rarely had past experience with engineering. Additionally, many teachers were not as familiar with the variety of pedagogical approaches available to integrate science and engineering, or all the STEM content areas, in meaningful ways (Goodnough, 2016).

Another identity tension that teachers experienced, especially when working with or observing practicing scientists and engineers, was the complex, non-linear nature of real-world science and engineering practices. Varelas et al. (2005), in their study of an RET program, noted that the participating teachers “recognized the messiness, complexity, and uncertainty of science-in-the-making, but hesitated, debated, wondered, and worried about the extent to which they could and should be enacting them in their classrooms” (p. 503). The teachers felt that science teaching was different from “authentic” science, due to students’ (lack of) knowledge and understanding of disciplinary core ideas and practices and students’ level of (dis)interest.

The teachers in the study also reported feeling that the time constraints of a school schedule and a lack of material resources precluded more inclusion of inquiry-based science practices (Varelas et al., 2005). Further, teachers felt hesitant to allow students to go through the process of struggle and failure inherent in real-world STEM contexts, partly because of the need for students to get the “correct” answers in their work and on assessments (Kapur & Bielaczyc, 2012; Varelas et al., 2005). Framing this as an identity tension, teachers reported that they felt that they had an “ethical and moral obligation to students” that could not be met through the use of authentic science practices alone (Varelas et al., 2005, p. 503).

A third tension in teachers’ STEM identities resulted from teachers’ own past experiences in STEM courses and with STEM content. Many teachers found the STEM disciplines to be challenging, and teachers were especially susceptible to their own and others’ narratives - especially those that are negative - about their abilities (e.g. “I am bad at math”; Avraamidou, 2019; Smith, 2005). Teachers often embraced these narratives as truth, without realizing that other possible narratives that were available (e.g., related to access, additional time, and more responsive types of instruction) and that their identities could change (Sfard & Prusak, 2005).

A final tension common in teachers' STEM identities involved extensive expectations imposed on STEM teachers to guide the integration of STEM subjects broadly and science and engineering specifically (Avraamidou, 2014). For instance, the number and range of standards and content teachers' are expected to teach in their content area(s). Additionally, many teachers found it difficult to implement or adapt their instruction in these content areas in such a way that they were accessible and relevant to the students in their classrooms, especially those who were linguistically, culturally, or ability diverse (Settlage et al., 2009).

Role Identity: Advocates and Change Agents

Teachers can be advocates and change agents in various ways in their professional roles. For the purposes of this study, I focus on teachers' identities and actions in this area as related to issues of social justice and equity that impact students, and especially those related to students' access to and participation in science and engineering disciplines. Ongoing inequitable educational policies and practices have resulted in increasing focus on teachers as advocates of their students' access to equitable education and change agents in helping to foster socially just practices (Pantić and Florian, 2015). Educational injustices in the US have included the overrepresentation of students of color in special education classes and in disciplinary actions, ongoing deficit perceptions and practices harmful to students of color, and the "racial disproportionality of teachers and students" (Souto-Manning, 2018, p. 2).

As several of these injustices are related to teacher actions, it follows that changes in teachers' role identities and resulting actions could foster more equitable educational experiences for students. The role identity of advocates and change agents also aligns well with the other focal identities: mid-career science and engineering teachers. Huberman (1989) characterized the mid-career years of teachers' professional life cycle as a time of experimentation and activism in the profession. Further, a key part of teachers' STEM identities is a focus on working with students to make an impact in their communities and a focus on equity and social justice (El Nagdi et al., 2018).

Characteristics of Teachers' Identities as Advocates and Change Agents

According to Pantić and Florian (2015) change agents "work purposefully with others to challenge the status quo and develop social justice and inclusion," (p. 333) and attend "to individual differences between learners while actively avoiding the marginalisation of some learners and/or the continued exclusion of particular groups" (p. 334). Teachers who act as change agents generally demonstrate four main characteristics (Pantić and Florian, 2015). These teachers include a commitment to social justice as part of their purpose as a teacher. They are competent in pedagogical approaches that are inclusive (e.g., CRT) and working collaboratively. These teachers understand and make use of their positions of power, for example through decisions they make in their classrooms or influence they have on inequitable school policies. Further, these teachers are reflexive and frequently and systematically interrogate and work to change their own and institutional practices (Pantić & Florian, 2015).

In relation to science and engineering education, an important part of teachers' identities in this area is advocating for underserved and underrepresented groups of students to have increased access to and more diversified options for participation in science and engineering courses and fields as well as supporting students in advocating for themselves and for their communities. Calabrese Barton and Tan (2019) highlighted the importance of the work teachers do to establish students' *rightful presence* in STEM. They defined rightful presence as a student's

> legitimate membership in a classroom community because of who one is (not who one should be), in which the practices of that community work toward and support restructuring power dynamics toward more just ends through making injustice and social change visible. (p. 3)

Through their work with teachers and youth, Calabrese Barton and Tan (2019) modeled action possibilities for fostering students' rightful presence through engaging youth as codesigners of engineering projects, generally related to students' communities and lives. By integrating the mandated teaching of disciplinary core content and engineering practices into these projects, teachers were able to "push back against the assumptions that knowledge, practices, and experiences of youth from nondominant communities are somehow lesser or deficient" (p. 11). In this way, teachers could enact the role of advocates and change agents through disrupting deficit narratives and fostering changes toward more equitable pedagogical approaches to engaging students in science and engineering through consequential, codesigned projects.

Common Tensions in Teachers' Identities as Advocates and Change Agents

Much of the scholarship related to teachers' role identities as advocates and change agents focuses on the tension between the external contextual forces in education and teachers' purposes and goals. Several researchers have emphasized the need for teachers to find their "voice" and to push back against normative authority that expects teachers to comply with the power structures and norms of specific schools or larger educational communities (e.g., Britzman, 1993; Rodgers & Scott, 2008; Zembylas, 2003) even if these structures and norms are inequitable. "Finding one's voice implies not having others (researchers, school boards, text books) speak for [teachers], not being silenced by authorities or normative notions of who teachers should be, in effect, to be the author of one's identity" (Rodgers & Scott, 2008, p. 737).

In terms of authoring an identity as an advocate and change agent, Pantić (2017) noted an additional tension: "Teachers' practices are highly contextualised and dependent on those of others, in ever changing constellations of human interactions located in complex, politically and culturally shaped educational settings" (p. 219). Thus, even if teachers report their commitment to social justice, they may "inadvertently contribute to the perpetuation of inequitable educational outcomes for some learners" if inequitable practices and policies are part of the contexts and cultures where they work or if they are unaware of their own, possibly inequitable, practices and assumptions (Pantić, 2017, p. 219). Thus, PD should facilitate teachers learning to "continually and critically reflect on the ways in which their personal and professional identities inform their (in)ability to effectively meet the needs of a diverse student population" (Carter Andrews & Richmond, 2019, p. 408). PD should also support teachers' awareness of systemic educational inequities which shape policy and practices.

Implications of Teacher Identity for PD

Scholarship on teachers' professional learning and development has often focused on increasing the content and pedagogical content knowledge, theoretical understanding, and pedagogical skills teachers needed to implement their learning into practice (e.g., Ball & Cohen, 1999; Shulman, 1986; Van Driel & Berry, 2012). While still acknowledging the importance of content, theory, and pedagogy, researchers have increasingly found that a teacher's professional learning and development involved more than a set of knowledge and skills (Beijaard, 2019). According to Wenger (1998), "Because learning transforms who we are and what we can do, it is an experience of identity" (p. 215).

Woods and Jeffrey (2002) explained further that there is "no direct route to changes in teaching and learning, restructuring education or raising educational standards. Such desired outcomes, however politically willed, have to be processed through teachers, who have feelings, values, beliefs, thoughts, cherished ideals; in short, identities" (p. 105). Teachers' identities shape how they act, their priorities, and whether and how they seek out PD opportunities (Hammerness et al., 2005). Additionally, teachers' identities affect how willing or able they are to embrace educational change and integrate new ideas into their practice (Beijaard et al., 2000).

Accordingly, those designing professional development (PD) should pay considerably more attention to teachers' existing beliefs and the tensions that arise when internal and external forces collide as an inherent part of change and growth (Beijaard & Meijer, 2017). When the enactment of professional development models ignore, discount, or work in opposition to teachers' identities, "education is the loser" (Woods & Jeffrey, 2002, p. 105). Engaging in identity work to try and "fit" into an externally-imposed reform or structure takes a great deal of emotional and intellectual energy that teachers could use for teaching and can ultimately lead to moral distance, fragmented identities, and principled leaving (Hargreaves, 2001; Santoro & Morehouse, 2011; Woods & Jeffrey, 2002). Instead, according to Sfard and Prusak (2005), learning within sociocultural contexts (e.g., a summer research apprenticeship for teachers) should seek to close the gap between individuals' actual (who teachers are) and designated (who they want to be) identities.

From my review of the literature on how professional development models do or should foster teachers' identity development, I identified three key implications for the design of the focal iteration of RESET. First, I needed to identify, acknowledge, and build on the four components of teachers' role identities (i.e., purposes and goals, beliefs, self-perceptions, and perceived action possibilities; Kaplan & Garner, 2017). This meant including learning experiences and reflection opportunities that encouraged mid-career teachers' continuing identity development in a way that went beyond checklists of actions to implement to foundational knowledge, beliefs, ideas, and goals (Beijaard & Meijer, 2017).

Second, I needed to focus on goals that were open-ended enough that teachers could achieve agency in how they enacted those goals based on who they wanted to be as mid-career culturally responsive science and engineering teachers. As Beijaard and Meijer (2017) argued, teachers should have the opportunity and agency to negotiate their own teacher identity, to "go public" with who they are as teachers, and to assess themselves against existing expectations and standards (p. 185). The teachers should be actively engaged in their own professional learning and the PD experiences should introduce a variety of new action possibilities to the teachers (Beijaard et al., 2004; Kaplan & Garner, 2017; Garner & Kaplan, 2019).

Finally, I needed to build in time and space for teachers to narrate and navigate tensions between who they were, who they wanted to be, and who they could be in their specific contexts. According to Beijaard and Meijer (2017), tensions could lead to learning opportunities and identity development when PD environments

> acknowledge that changing beliefs and how one sees him/herself personally and professionally feels inherently unsafe and resisting such change should be taken seriously; [are] a safe environment for, in essence, unsafe learning; include an atmosphere of openness and respect in combination with dialogues and narratives; include a variety of dialogues: self-dialogue, peer-dialogue and supervisory dialogue. (p. 188)

Therefore, critical discussions in which teachers have space to address uncertainty and resist, grapple with, and adapt ideas being shared or discovered, were a focal component of the teachers' experiences in RESET.

According to Danielewicz (2001), "The bottom line is that no matter what the context, we are continually engaged in becoming something or someone" (p. 10). As the purpose of the RESET PD was to help mid-career teachers "become" culturally responsive science and engineering teachers, the next section of this chapter focuses on what it means to be culturally responsive. I briefly describe the history of this construct and situate it within the broader context of social justice and equity in education.

Culturally Responsive Teaching

Culturally responsive teaching (CRT; Gay, 2000) belongs to a group of resource pedagogies developed over the past several decades. Resource pedagogies aim to counter deficit approaches to educating students, in which linguistically, culturally, racially, or ability diverse ways of being are viewed as deficiencies to overcome in favor of imposed dominant cultures and practices (Paris, 2012). Instead, social justice and equity are the central features of resource pedagogies, which seek to foster "structural and systemic changes in the total school...to increase educational equality" (Banks, 1993, p. 20), challenge racism, implement critical pedagogy to promote social change (Nieto & Bode, 2018) and counter deficit narratives with recognition of students' differences as assets (Gay, 2013; Paris, 2012). Resource pedagogies are generally rooted in the scholarship of multicultural education (Banks, 2013), and build on the foundational work of many other scholars, including Au (1980), Moll and colleagues (1992), and Nieto (1999).

CRT is similar in many ways to Ladson-Billings' (1995) *culturally relevant pedagogy* and Paris' (2012) *culturally sustaining pedagogy* (Kelly et al., 2021). All three share a strong commitment to "social justice and the classroom as a site for social change" (Aronson & Laughter, 2016, p. 163) and empowerment for students, though these components have largely been absent from research and materials claiming to be culturally responsive, relevant, or sustaining (Paris & Alim, 2014). For this study, I chose to focus specifically on Gay's (2000, 2010, 2013, 2018) CRT, including her terminology and definitions. Gay (2010) defined CRT as "using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them" (Gay, 2010, p. 31). This approach also focuses on creating community amongst individuals from different cultural, social, and ethnic backgrounds and fostering students' agency, efficacy, and empowerment (Gay, 2013). Therefore, CRT aligned well with the targeted outcomes of the RESET PD.

Intersectionality

Gay (2018) focused CRT primarily on the "academic achievement of ethnically, racially, culturally, and socially diverse students (e.g., students of color)" (p. xxxii). Gay also noted that this was not an exclusive focus, because academic achievement is also connected to "other aspects of functionality, such as personal attributes, cultural orientations, political conditions, social class, economic background, and psycho-emotional dispositions" (p. xxxii). In other words, CRT must consider the diverse intersectionalities of students.

Intersectionality is a term originally published by Crenshaw (1989). Intersectionality

> holds that the classical models of oppression within society, such as those based on race/ethnicity, gender, religion, nationality, sexual orientation, class, species or disability do not act independently of one another; instead, these forms of oppression interrelate creating a system of oppression that reflects the 'intersection' of multiple forms of discrimination. (Ritzer, 2009, p. 1; as cited in Grant & Zwier, 2011)

Intersectionality addresses how various forms of oppression (e.g., classism, racism, sexism) overlap and shape our experiences in the world. Specifically, as related to this study, Boveda and Weinberg (2020) explained the importance of considering intersectionality in relation to the disparate opportunities and representation of groups in science disciplines. Social justice in education centers in "how teachers understand who their students are and how they view and respond to their students - in all of their complexity - to foster learning and growth" (Pugach et al., 2019, p. 206). Thus, educators must examine how their own and students' sociocultural identities interconnect and influence their decisions and practices in the classroom (Boveda & Weinberg, 2020). Accordingly, in this dissertation study, I adopted the view of CRT as being responsive to students' (and teachers') intersectionalities.

Attributes of CRT

The attributes of CRT provide a framework to help educators integrate an explicit focus on issues of social justice and equity into a PD as well as providing teachers participating in the PD with a framework for integrating responsive and equitable practices into their classrooms. The main attributes of CRT include:

- Culturally responsive teachers are *socially and academically empowering* by setting high expectations for students with a commitment to every student's success;
- Culturally responsive teachers are *multidimensional* because they engage cultural knowledge, experiences, contributions, and perspectives;
- Culturally responsive teachers *validate every student's culture*, bridging gaps between school and home through diversified instructional strategies and multicultural curricula;
- Culturally responsive teachers are *socially, emotionally, and politically comprehensive* as they seek to educate the whole child;
- Culturally responsive teachers are *transformative of schools and societies* by using students' existing strengths to drive instruction, assessment, and curriculum design.

- Culturally responsive teachers are *emancipatory and liberating from oppressive educational practices and ideologies* as they lift "the veil of presumed absolute authority from conceptions of scholarly truth typically taught in schools" (Gay, 2010, p. 38). (Aronson & Laughter, 2016, p. 165)

In the most recent edition of *Culturally Responsive Teaching*, Gay (2018) added two additional attributes: *humanistic* and *normative and ethical*. CRT is *humanistic* in that it is "ultimately concerned with the human welfare, dignity, and respect" of all students (Gay, 2018, p. 44). CRT is *normative and ethical* in that it extends deserved "parallel rights and opportunities like those received by majority group students" to students "from other ethnic groups, especially those discriminated against, oppressed, and marginalized" (Gay, 2018, p. 45). Together, the eight descriptors of CRT, represent key ideas about how to adapt classroom instruction to be more responsive to students' sociocultural orientations.

Implications of CRT for PD

CRT must be shaped by the sociocultural contexts and people in the settings where it will be implemented" (Gay, 2013). Curricula, resources, and pedagogical practices cannot be inherently culturally responsive. They have to be responsive *to someone*. Ladson-Billings (2008) explained to future teachers that she did not want to tell them how to enact CRT "because you would probably do exactly what I told you to do" (p. 39) instead of adapting ideas to the needs of their students. CRT is not a specific method or set of strategies, but rather teachers' critical stance toward inequitable social structures (Schmeichel, 2012).

When teachers adopt CRT, they commit to a “pedagogical approach that aims to see, understand, and love the whole child” (Martinez et al., 2017, p. 486). Teachers need to get to know their students before making judgements about the responsiveness of texts, curriculum, or pedagogical approaches (Kelly et al., 2021). Teachers must know their students’ lives in order to avoid trying to fit students in cultural boxes or specific identities (Paris, 2012; Schmeichel, 2012).

Thus, designing a professional development to help teachers learn or strengthen culturally responsive practices must focus on key ideas and principles rather than specific methods, resources, or activities. PD models should support teachers’ increased awareness of social justice issues and inequities, or making the invisible visible (Bang & Vossoughi, 2016). Additionally, PD should support teachers in recognizing that culture, race, and differences are normative and not inherently value-laden; in countering deficit narratives; and in acknowledging the serious and historical nature of the problems while actively working to do something about them (Gay, 2013; Ladson-Billings, 2014).

Design-Based Research

Because of the complex and fluid nature of teachers’ identities and the enactment of CRT, as well as the lack of PD models focused on these topics in relation to mid-career K-8 science and engineering teachers’ identities, practices, and actions, the methodological approach I chose for my dissertation study was design-based research (DBR). DBR approaches, at least as recognized in the educational research community in the US, began in the early 1990s. These approaches included design experiments (Brown, 1992; Collins, 1992), educational design research (McKenney & Reeves, 2013; Plomp, 2013), and design-based research (Hoadley, 2002; Design Based Research Collective, 2003). DBR also shares many features with other approaches, such as design-based implementation research (Penuel et al., 2011), social design experiments (Gutiérrez & Jurow, 2016), and participatory design research (Bang & Vossoughi, 2016). While these approaches share many similar elements, processes, and purposes, it is beyond the scope of this study to overview all the similarities and differences. For simplicity and clarity, I have chosen to use the term *design-based research (DBR)* throughout this paper.

Researchers have also used different or multiple labels to describe DBR: a series or family of approaches, a methodological framework, a group of methods, a paradigm, or a methodology (Barab & Squire, 2004; Collins et al., 2004; DBR Collective, 2003; Phillips, 2006). As there is no clear consensus, I generally use the term *approach* throughout the paper, occasionally referring to specific *methods* within the DBR approach. In the following sections, I overview the characteristics and purposes of DBR. I then explain common critiques of DBR, including both strengths and weaknesses.

Characteristics of Design-Based Research

The scholarship on design-based research in education has generally defined DBR using varying combinations and versions of four key elements. First, according to McKenney and Reeves (2013), a DBR study originates from a problem of both theoretical and practical significance. There is a difference between problems of education that can be studied in authentic educational settings and those focal to DBR studies. Bakker (2018) explained that DBR researchers focus on a specific type of problem where the proposed solution or learning intervention is not yet occurring in the naturalistic educational setting (Bakker, 2018, p. 3) and, therefore, must be designed. In their DBR study of a science and engineering research experience for teachers (RET) professional development (PD), for example, Hardré and colleagues (2010) sought to address the lack of PD opportunities relevant to both specific teachers' and students' needs in order to facilitate transfer from the PD to classroom practice.

In a second key element, DBR researchers engineer innovative educational interventions and environments in collaboration with educators to attempt to solve these problems (Brown, 1992). Researchers, educators, or other stakeholders might see the potential of a new digital technology, strategy, curriculum resource, or professional development to improve the learning and teaching of students and teachers (Bakker, 2018). As one of the pioneers of DBR in the US, Brown (1992) conducted *design experiments* through which she created new educational environments through implementing designed interventions while simultaneously studying this process. Thus, in DBR, the researcher (or others as discussed further in a later section) collaborates with practitioners to implement what is hoped to be an innovative, designed intervention in a way that is useful and practical. For example, in two different studies detailed in the previous paper, researchers designed professional development programs for science teachers to foster the teachers' growth as culturally sustaining educators (Brown & Crippen, 2016) or educators attuned to and enabling students' diverse ways of making sense of science (Rosebery et al., 2016). These researchers then studied the enactment of their respective PD models, focusing on if and how it impacted participating teachers' learning and practice.

Third, DBR researchers generally implement engineered interventions using iterative cycles of design, enactment, analysis, and redesign (DBR Collective, 2003). These iterations allow researchers to respond to what is happening in the context related to the implementation of the intervention. Further, according to Hoadley (2002), iteration is fundamental to understanding how a specific design based on broad theoretical principles interacts when it is implemented and adjusted in local contexts in order to better understand and advance the theory. It is the researchers' ability to change aspects of the design that allows them to develop understanding of how the intervention is or is not working and which aspects of a design might impact certain learning outcomes. Rosebury et al. (2016) demonstrated this ability by implementing their science sense-making PD with one group of teachers, studying the results, and adjusting the intervention to have a greater focus on helping teachers identify social justice and power issues in their own practices. They then implemented the adapted version of the PD with a new group of teachers in a second iteration.

A final key element of DBR centers on its dual aims of utility in local context as well as developing or furthering the theoretical knowledge of the field by generating theoretical conjectures and then putting them "in harm's way" (Cobb et al., 2003, p. 10). Barab and Squire (2004) explained that DBR extends beyond designing and testing innovations simply to see if they work. Rather, the designed interventions should be grounded in theoretical understanding of teaching and learning to allow researchers to examine relationships between theory, practice, and the designed interventions (Bielaczyc, 2013; DBR Collective, 2003). In other words, the design must be both practically useful and theoretically meaningful.

In preparing to conduct DBR, researchers first consider the theoretical intent or purpose of the study (Cobb et al., 2003). Sandoval (2014) refers to the theoretical intent as a *high-level conjecture*, or a general, theory-based idea of how to support a targeted form of learning or other *outcomes*. Designers of teacher PD generally have the theoretical intent of supporting teachers' learning in a specific area and develop a theory-based conjecture of how to do so (e.g., Hardré et al., 2010; Rosebery et al., 2016). Researchers at this stage become "tinkerers" using all the material at hand, drawing from theoretical insights, previous research literature (if available), their practical experience with education and design, their understanding of current practices and resources being used, and their knowledge of participants' skills and understandings (Cobb et al., 2003; Gravemeijer, 1994). All of this "tinkering" informs the design of an intervention with a hypothesized trajectory of learning toward designated outcomes (Cobb et al., 2003). According to Van den Akker (2013), this process can result in *design principles*, or statements about the "what" and "how" of interventions that offer both "theoretical explanations and empirical underpinning to justify these knowledge claims" (p. 67).

To reify researchers' conjectures, theories, and learning trajectories, Sandoval (2014) suggested creating conjecture maps. These "maps" are "a means of specifying theoretically salient features of a learning environment design and mapping out how they are predicted to work together to produce desired outcomes" (p. 19). In addition to the high-level conjecture and outcomes, conjecture maps generally include several other elements: the *embodiment* (Sandoval, 2014) or *design features* (Boelens et al., 2020) and *mediating* (Sandoval, 2014) or *enactment* (Boelens et al., 2020) *processes* of the design. Conjecture maps also usually include *theoretical* (Sandoval, 2014) or *process* (Boelens et al., 2020) *conjectures*, *design conjectures*, and expected *connections* amongst these elements. The embodiment or design features of the intervention includes the structures, practices, and resources hypothesized to lead to the mediating or enactment processes.

These processes show how researchers hypothesize that participants' activities and interactions will lead to the outcomes (Boelens et al., 2020; Sandoval, 2014).

The theoretical and design conjectures of a DBR study focus on ideas researchers have about how the embodiment of the design produces mediating processes and how the mediating processes lead to outcomes (Bakker, 2018). Conjecture maps allow researchers to be as clear as possible in advance about their ideas of how design will support specific types of learning, to test their predictions, and to refine both the design and theories in response to what actually happens in the implementation of an intervention (Sandoval, 2014). In short, these maps help to guide the DBR study and to make researchers' decisions visible and trackable.

Purposes of DBR

Researchers developed design-based approaches in an attempt to address various problems or weaknesses of educational research or education generally (Bakker, 2018). For example, other approaches to educational research generally occurred in laboratory-like, controlled settings rather than in the reality of authentic, complex educational environments, limiting the utility of the findings (Gutiérrez & Jurow, 2016, Sandoval & Bell, 2004). Further, educational research often focused on results (i.e. what worked) rather than processes (i.e., how and why it worked), making it difficult to advance theory or create easily-adaptable interventions. Therefore, as Shavelson et al. (2003) explained, DBR attempts to "trace the evolution of learning in complex, messy classrooms and schools," in order to build and evaluate educational theories and design instructional tools that "survive the challenges of everyday practice" (p. 25).

Another focal purpose of DBR is to design for the future of education "as it *could be* or even how it *should be*" (Bakker, 2018, p. 3, emphasis in original), rather than focusing exclusively on current or past aspects of education. In sum, design-based approaches allow researchers to systematically study how educational interventions are designed and enacted as solutions to specific educational problems within authentic contexts (Plomp, 2013). Further, DBR allows researchers to advance knowledge and theories about why and how designed interventions work and to iterate and adjust if they do not work (Barab & Squire, 2004).

Critiques of DBR: Strengths and Weaknesses

The majority of the critiques of DBR fall into three main categories, depending on the epistemological and ontological beliefs of those critiquing the approach: 1) DBR varies too far from experimental research to make causal or generalizable claims (e.g., Shavelson et al., 2003); 2) DBR allows researchers to address problems that those in other approaches have struggled to address (e.g., Hoadley, 2004); and 3) DBR remains too researcher-driven and hegemonic (e.g., Bang & Vossoughi, 2016; Engeström, 2011). As these various critiques often differ widely in what they consider to be the strengths and weaknesses of DBR, I will address each individually.

The first category of critique centers on the differences between DBR and quantitative, experimental methods (especially randomized control trials). Though this critique is common to many forms of qualitative research, some features specific to DBR are seen as especially problematic. Sandoval and Bell (2004), as DBR researchers themselves, acknowledged the tension between changing an intervention as it is enacted in order to make it "work" in a complex educational setting and the idea of empirical control which argues against such change. Further, Shavelson et al (2003), “in the spirit of supporting, building, and improving” (p. 25) DBR, wondered if knowledge claims from DBR studies were warranted, given that there are so many confounding variables. As Brown (1992) quipped, the complexity of studying learning in authentic environments, “presents a methodological headache for traditional psychology, allergic as it is to multiply confounded experiments” (p. 166).

In an attempt to address some of these concerns, DBR researchers often use extensive analysis and detailed narrative accounts of any learning that occurred in the study, how learning was supported, and iterations that were made and why. However, Shavelson et al. (2003) felt these accounts did not adequately address the issues of confounded variables and iteration. Specifically, concerned researchers question whether narrative accounts address the extent to which other rival narratives of the same action could be ruled out, as well as the replicability and generalizability of results in other contexts (Coburn, 2003; Sandoval & Bell, 2004; Shavelson et al., 2003). However, Cronbach (1975) asserted that, across research methodologies, “when we give proper weight to local conditions, any generalization is a working hypothesis, not a conclusion” (p. 125), implying that this concern was not specific to DBR.

Additionally, Anderson and Shattuck (2012) detailed challenges surrounding the role of the research as an interventionist and collaborator, rather than an observer. These authors argued that this positioning might bias the findings or tie the intervention so closely to the researcher, that it is discontinued when the researcher leaves. Finally, the open-ended, iterative nature of DBR studies makes it difficult to know when (if ever) the research is “done” (Anderson & Shattuck, 2012; Engeström, 2011).

The second category of DBR critiques is generally positive, seeks to address some of the methodological issues posed in the last category, and centers around the problems in other educational research methodologies that design-based studies attempt to address. For example, in response to the criticism of not controlling for confounding variables, Barab & Squire (2004) noted that DBR studies seek to develop adaptable theories that can be used in new contexts, not because researchers somehow managed to control for all variables, but "because the theory is supple enough to maintain its robustness even in the context of changing situational variables" (p. 11). Further, Hoadley (2004) argued that DBR helps researchers to better align their methods and to connect interventions to outcomes in complex contexts such as classrooms better than experimental research could in these settings, as data sources and analysis specifically focus on processes as well as outcomes.

In addition to presenting their concerns about DBR, Shavelson and colleagues (2003) noted that DBR's strengths include testing theories in "the crucible of practice" (p. 25) and working closely and collaboratively with practitioners to co-construct knowledge. Further, they continued, DBR allows researchers and practitioners to focus on and address pressing issues which impact local classrooms, schools, and communities. Overall, Shavelson et al. concluded that the strength of DBR was "in recognizing the limits of theory…capturing the specifics of practice and…iteratively adapting and sharpening theory in its context" (p. 25). Other researchers also mentioned the bridging of theory and practice as key strengths of DBR (e.g., Barab & Squire, 2004; Cobb et al., 2003; DBR Collective, 2003).

The final category of critiques of DBR emerged mostly within the last decade and centers on DBR's researcher-driven interventions as reinforcing traditional power structures. According to Engeström (2011), the tacit assumption in DBR seems to be that researchers will design an intervention, then implement and modify it, and students' learning improves as a result. This linear approach, he continues, overly simplifies the process of learning and scholars generally neglect to ask "who does the design and why?" (p. 600). Long (2001) emphasized the often ignored or invisible dimensions of an intervention, including internal organization and conditions, political dynamics, and responses of groups "who may struggle to define and defend their own social spaces, cultural boundaries and positions within the wider power field" (p. 27).

In response to these concerns and weaknesses of DBR, some researchers have begun to propose and implement adapted or alternative forms of DBR. One such approach that has strong applicability to aspects of my study is *social design experiments* (Gutiérrez & Jurow, 2016), which focuses on issues of social justice and equity and seeks to address these through collaborative design research. Gutiérrez and Jurow (2016) were concerned by DBR studies' lack of attention to issues of social justice and equity for non-dominant student populations. Therefore, while they embraced the basic structure and goals of DBR, they also included "a commitment to transforming the educational and social circumstances of members of non-dominant communities as a means of promoting social equity and learning" (Gutiérrez & Jurow, 2016, p. 1). Further, while DBR studies generally function within existing institutions (e.g., schools), social design experiments seek to transform institutions by creating opportunities for nondominant populations outside of existing institutions (e.g., summer programs, community gardens; see also DiGiacomo & Gutiérrez, 2017)

In the next section, I briefly synthesize five example articles that include one or more of the concepts central to my dissertation study (e.g., DBR, CRT, teacher identity, PD) and that illustrate implications and possibilities for the design of RESET.

Example PD Studies

The researchers in two of the five example PD articles I selected used a DBR approach to design, implement, and research teacher PD. Brown and Crippen (2016) designed a six-month PD program that involved high school life science teachers. Their goal was to support these teachers' growth as culturally responsive educators and to determine which experiences they included in the PD most impacted teachers' culturally responsive classroom practice. Similarly, Rosebery and colleagues (2016) conducted a mixed methods DBR study of a 30-hour science PD they created and implemented with 26 early career teachers (less than five years of experience) across two iterations. Though not specifically tied to CRT, the goal of the PD was to help participating teachers to develop expansive pedagogical practices that encouraged and built on students' ideas and perspectives, challenged normative hierarchies and ways of knowing, and expanded opportunities for minoritized students.

Another two of the studies reviewed models of teacher education or PD related to social justice and activism. Kohli et al. (2015) reviewed three models of grassroots, critical PD, in which teachers were "positioned as experts in their own social justice-oriented professional growth" (p. 9). The goal of the critical PD models was to help teachers develop critical pedagogies and culturally relevant pedagogies that supported students' intersectionalities. Oyler and colleagues (2017) reviewed specific attempts in teacher education to help teachers develop an activist teacher identity, or in other words, to become advocates and change agents.

The final example was Severance et al.'s (2016) study. Though this research study was not specifically focused on social justice or CRT, the PD aimed to help teachers achieve agency in the creation of science curricula units, one of the key tasks of the teachers in an RET program. In this study, 16 secondary school science teachers participated in the design of science units aligned with the NGSS standards. Other stakeholders (e.g., administrators, researchers, community members) were also actively involved in the project.

Three of the example studies highlighted features included as part of the PD design which targeted the specific goals and outcomes of the various PD models. In one study, teacher participants engaged in a variety of experiences during the PD, such as lesson study, developing a culturally responsive science unit, and analyzing their own practices and students' learning (Brown & Crippen, 2016). Rosebery et al. (2016) engaged teachers in critique routines of classroom practices and examples. Half of the teachers participated in the first iteration of the PD and half in the second. The major changes between iterations included an increased focus on social justice and power issues and helping teachers identify these issues in their own and others' practices. Severance and colleagues (2016) engaged the group of teachers and other stakeholders in an initial week-long workshop introducing them to a curriculum design tool they could use and allowing them to plan their group's design work over the course of the school year. As in this dissertation study, all three of these studies included a direct connection to teachers' own practices and curriculum related to science teaching, with both Brown and Crippen and Rosebery and colleagues specifically focusing on how these practices were responsive or relevant to students and focused on social justice.

In the other two articles, researchers highlighted salient design features found through their reviews of the literature related to critical PD (Kohli et al., 2015) and teacher education for social justice activism (Oyler et al., 2017). Grounded in Freire's (1970) theory of oppression and framework of dialogical action, Kohli and colleagues found critical PD was designed to "provoke cooperative dialogue, build unity, provide shared leadership, and meet the critical needs of teachers" (p. 11). Oyler et al. argued that teacher education which supports teachers as change agents and activists needs to require that teachers actually do something in the fight for a more just world. Thus, these articles emphasized the importance of focusing on teachers' needs in PD and then continuing to support teachers in enacting their roles as change agents and activists.

Across the five articles, researchers used a variety of methods. For example, in terms of data sources, several of the researchers used interviews with the teachers; program artifacts, including designed lesson or unit plans or a transcript analysis task; and observational data, such as video recordings or field notes of specific activities (Brown & Crippen, 2016; Rosebery et al., 2016; and Severance et al., 2016). These researchers used this data to determine direct connections between targeted outcomes and specific PD activities (Brown & Crippen, 2016; Rosebery et al., 2016; Severance et al., 2016), while the other researchers compared existing PD or teacher education models to determine how to support teachers in interrupting oppressive PD and educational practices (Kohli et al., 2015; Oyler et al., 2017).

The five example articles included a wide range of findings related to the design and enactment of the RESET PD intervention. Many of the researchers found that engaging the teachers in critical discussions and examination of their own practices and needs in relation to their students' intersectionalities resulted in positive progress toward the PD's targeted outcomes. These outcomes included teachers' integration of culturally responsive practices into science instruction (Brown & Crippen, 2016) and teachers' ability to interpret students' diverse sense-making in science as well as to discuss their own students' work and understanding (Rosebery et al., 2016). Other positive outcomes included teachers' increased ability to engage in authentic dialogue about inequities and to focus on caring and respect of those across a variety of roles (Kohli et al., 2015) and teachers' development of an activist teacher identity (Oyler et al., 2017). Severance and colleagues (2016) found that, for the most part, the teachers involved in learning about and designing curriculum agentively decided not to follow the exact structure of the curriculum design tool they were given but were able to efficiently organize and move through the design process.

In addition to these positive outcomes, the researchers also discussed common tensions in PD which they encountered. For example, Severance et al. (2016) reported that one curriculum design group struggled with the more open-ended, agentive process, so researchers and administrators decided to add a facilitator to the group. Though this solved many of the issues, it led to a discussion about the impact on teachers' agentive actions when researchers and administrators stepped in. Further, Severance et al. addressed the tensions of trying to allow for teachers' agentive action within a funded project with specific expectations. Oyler et al. (2017) also focused on this type of tension between PD goals and external, contextual constraints, noting that it was especially challenging for teachers to navigate “the tension between the implicit goals of public education for societal reproduction and the societal transformation goals of teacher education for activism” (p. 229).

While there are additional studies of PD models that include similar features to those I am focusing on in RESET, I found these studies especially useful as models. Each study was a rich source of measurement tools, ideas, findings, and specific experiences to adapt for my study. In the next chapter, I provide the specific details regarding the methods I selected and implemented in this dissertation study.

CHAPTER 3

METHODS

This chapter includes a description of the research methods used to guide the design, implementation, and analysis of the Responsive and Empowering Science and Engineering Teachers (RESET) PD intervention. I first introduce the Solar Energy Engineering Research (SEER; pseudonym) summer program to establish the broader PD context within which the RESET intervention is embedded. I then explain the study's DBR approach and the iterative process of designing the research-grounded RESET intervention through conjecture mapping (Boelens et al., 2020; Sandoval, 2014). I then overview the resulting design and implementation of the RESET PD intervention within the broader SEER program in Year 3. Data sources, collection, analysis methods are then explained. Throughout this chapter, I include several tables and figures to help illustrate the multiple components of the SEER program and the RESET intervention.

SEER Summer Program

The SEER summer program has taken place each of the past seven summers at a university in the southwestern United States at an NSF-DOE grant-funded Engineering Resource Center (ERC) and in solar energy engineering laboratories located near the university. For the purposes of this study, I focused on the SEER program as it has been implemented for the past three years, under a new Education Program Director, Dr. Michelle Jordan. I also became involved in the program three years ago, as a graduate research assistant to Dr. Jordan. Over time, I have taken on additional roles as a co-designer and facilitator. I provide details of how I enacted and navigated these various roles throughout this chapter. For the purposes of this study, I refer to the first year that

Dr. Jordan directed the SEER program as Year 1. Accordingly, I have been involved in the program for Years 1, 2, and 3.

SEER includes four sub-programs designed for different groups of students and teachers (see Table 3). Those interested in the SEER summer program must apply and then be selected to participate in one of the programs.

Table 3

SEER Sub-Programs Overview

SEER Sub-Programs	Participants	Participants per Summer	Selected From[a]	Length of Program
Research Experience for Teachers (RET)	Inservice K-12 teachers	6-10	In state (most local)	5 weeks (M-F)
Research Experience for Undergraduates (REU)	Undergraduate STEM majors	10-14	United States	8 weeks (M-F)
Young Scholars (YS HS)	10^{th}-12^{th} grade high school students	2-5	Local high school districts	5 weeks (M-F)
Youth Scholars (YS MS)	7^{th}-9^{th} grade middle school students	10-12	Local K-8 partnership school district	6 days over 5 weeks

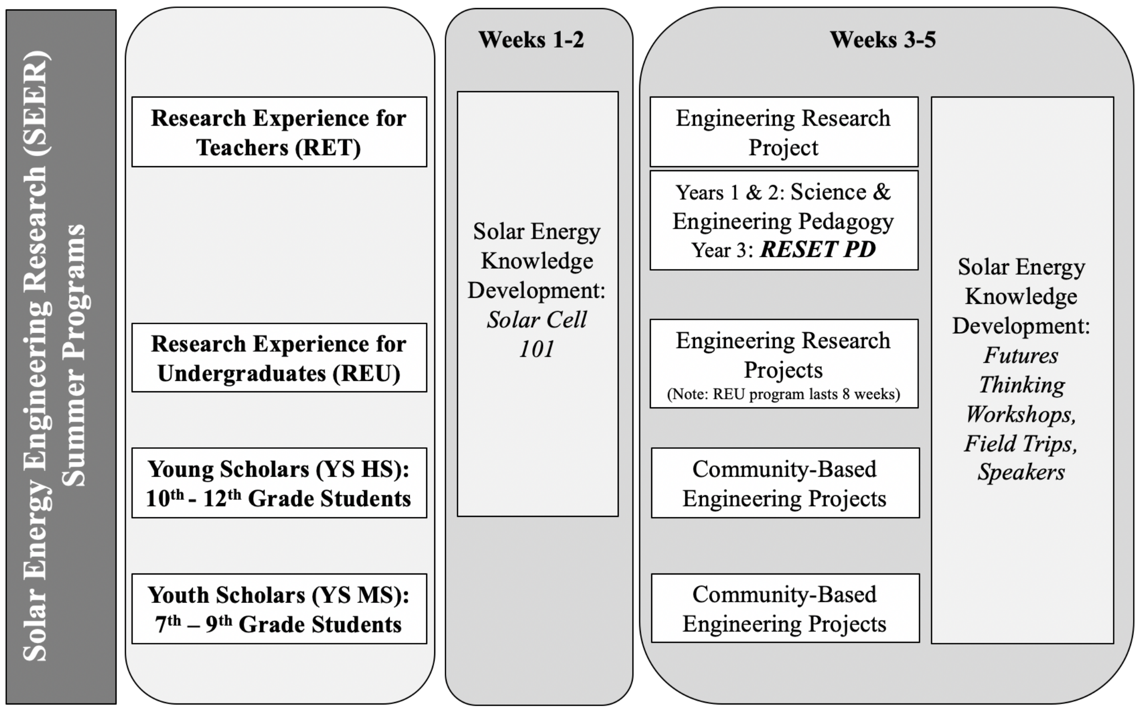
[a] Relative to the SEER program host university

The purpose of SEER is to engage students and teachers in authentic solar engineering research and design experiences in order to build their knowledge of science and engineering broadly and solar energy science and engineering specifically. Thus, each of the four sub-programs includes two main components: solar energy knowledge development and engineering research projects. Participants across sub-programs participate in activities related to solar energy knowledge development together in a heterogeneous group. Group members participate in engineering research projects with members of their same sub-program. The RET program includes a third component:

science and engineering pedagogy. The RESET PD was embedded within the pedagogical component in Year 3 (see Figure 2).

Figure 2

SEER Sub-Program Overview and Timeline



In this study, I focus *only* on the RET program's participants and the design of the RESET intervention. However, a key part of SEER is the ongoing formal and informal interactions between the teachers in the RET and the group members in the other three programs. Therefore, I will first describe the RET, then include a brief overview of the other sub-programs.

Research Experience for Teachers

The Research Experience for Teachers includes K-12 teachers from areas near the university or from rural areas of the state. The teachers spend the first two weeks of the program learning solar energy content and engaging in the process of solar cell fabrication in a clean room laboratory with other SEER participants. This experience is called *Solar Cell 101* by program directors. The teachers spend the final three of their five weeks in the program working with engineers, engineering faculty, and engineering graduate student mentors to move forward an authentic engineering research and design project that can be used in their classrooms with students to varying extents.

During the same three weeks that the teachers are working on their research projects, teachers also participate in curriculum design and pedagogical workshops facilitated by the SEER's education director and education graduate students to help them transfer what they are learning about engineering through their project into curricula materials (e.g., lesson or unit plans and needed supporting materials) specific to the grade and content they teach. All teacher-participants are expected to implement their developed curriculum in their classrooms sometime during the school year following program participation.

Research Experience for Undergraduates

The Research Experience for Undergraduates (REU) includes college students from across the US, who are majoring in a STEM discipline. The undergraduates participate in Solar Cell 101 with members of the other sub-programs. They are then assigned to work in pairs with PV engineers and graduate student mentors for the remainder of their eight weeks in the program, assisting with mentors' solar engineering research projects.

Young Scholars: High School Students

The Young Scholars (YS HS) program includes local high school students, generally entering 11th or 12th grade the following school year, interested in pursuing further education and careers in science and engineering fields. After participating in Solar Cell 101, these students are assigned to work as a group with engineering mentors on a solar energy engineering project. During the summers of Years 2 and 3, an additional YS HS group of four (Year 3) or five (Year 2) high school students continued work on a self-initiated community-based engineering research and design project - a solar pavilion for a middle school in their district - begun during their earlier participation in the YS MS program in Year 1. All YS HS students participate in the SEER program for the same five weeks as the teachers and work with a variety of engineering and education mentors.

Youth Scholars: Middle School Students

The Youth Scholars (YS MS) program is set up and functions differently than the other three programs, mostly due to the age of the participants. The participating students attend or just completed middle school (i.e., entering 7th to 9th grade). The students all come from a SEER partnership Title I district located near the university. All of the participating students are recruited by teachers in this district based on their interest in science and engineering and in participating in the summer program.

A former RET participant and eighth grade science and engineering teacher from the same district, Jade Whipple (pseudonym), facilitates the YS MS program. Unlike the other groups, who participate in the program each weekday over five to eight weeks (i.e., approximately 25 or 40 days), the YS MS program takes place on a total of six days spread across the same five weeks of the YS HS and RET programs. On each of these six days, Jade and the students are bussed to the university ERC or the solar engineering laboratories. YS MS participants learn about solar energy engineering and design engineering projects focused on aspects of environmental sustainability, often centered in their own communities. Though much of their time is spent working on their projects, the middle school students also have the chance to interact with the other groups and mentors at times.

Additional Program Information

Participants in the RET, REU, and YS HS are provided with a stipend and needed supplies (e.g. cleanroom laboratory notebooks, research project supplies, poster printing) for their participation in the program. The undergraduates and teachers who do not live locally stay in the university dorms and receive a food allowance. Participants in the YS MS program are provided with bussing to and from the university as well as snacks, meals, and supplies for the six days of their program. A culminating research poster session where the undergraduates, teachers, and YS HS students can present their work from the SEER program is held on the last day of the REU program each summer.

Research Context: SEER Year 3

This study took place during the SEER program held in the summer of Year 3. The RET, REU, and YS HS programs began on May 29. The RET and YS HS programs ended on July 3. The REU program continued through July 25. The eight REU students, six YS HS students, and six RET teachers participated in the SEER programs Monday through Friday from approximately 9:00 a.m. to 5:00 p.m. The YS MS program was held on May 31, June 6, June 14, June 21, June 28, July 2, with the nine students, one student mentor, and program facilitator arriving at the university or solar labs around 9:00 a.m. and leaving about 3:30 p.m. An overview of the program timeline, activities, and locations is provided in Table 4.

Table 4

Year 3 SEER Program Timeline of Events

<table>
<tr><th>Date</th><th>RET, REU, and YS HS[a] Program Events</th><th>Date</th><th>YS MS[a] Program Events</th></tr>
<tr><td>May 29</td><td>SEER Program Orientation</td><td>May 31</td><td>SEER Program Orientation</td></tr>
<tr><td>May 30 - June 10</td><td>Solar Cell 101</td><td>June 6</td><td>Introductions & Community Building: YS MS and RET</td></tr>
<tr><td>June 11 - July 3</td><td>Engineering Research Projects</td><td rowspan="2">June 14, June 21, June 28, July 2</td><td>Engineering Research Projects</td></tr>
<tr><td>June 11 - July 3</td><td>Cross-Program Events: Lab meetings, field trips, speakers, futures thinking</td><td>Participated in several cross-program events on the days of their program</td></tr>
<tr><td>June 11 - July 3</td><td>Science & Engineering Pedagogy: RESET PD (RET ONLY)</td><td>N/A</td><td>N/A</td></tr>
<tr><td>July 25</td><td>Final Poster Session</td><td>N/A</td><td>N/A</td></tr>
</table>

[a] Unless otherwise specified

On the first day of the SEER program, the RET, REU, and YS HS group members met as one group on the university campus with the program directors and some education and engineering mentors. The group spent the day participating in program and content orientation sessions, getting to know one another, and completing paperwork and pre-measures. The following day, the group moved to the solar laboratories located near the university to receive lab safety training and tour the clean room laboratory where they would be learning how to fabricate solar cells.

Solar Cell 101

The RET, REU, and YS HS group members then spent the following seven weekdays developing their solar energy science and engineering knowledge through Solar Cell 101. The full group met together each morning for daily instructions or instructional presentations by engineering mentors. For the remainder of the day, they worked in assigned groups of three. These heterogeneous groups included one RET teacher, one REU student, and one YS HS student or one RET teacher and two REU students. Group members were assigned to heterogeneous groups in order to allow group members' individual strengths (e.g., content knowledge, leadership, familiarity with technology) to contribute to the learning and progression of the whole group. Each group of three worked together in the clean room laboratory with engineering mentors, learning about and engaging in the eight steps of manufacturing and testing their own solar cells.

Each group of three also worked together outside of the laboratory, using software to digitally model various parameters of a solar cell in order to try and increase a solar cell's efficiency. On the final day of Solar Cell 101, each group of three gave a 10-minute presentation explaining one of the fabrication processes they learned in the laboratory, the efficiency of the solar cells they created, and their most efficient digital model for a solar cell. Mentors and other group members provided feedback on these presentations and each group's work in order to further build their knowledge of solar energy moving into engineering research projects.

Engineering Research Projects

Beginning on June 11, and for the remaining three weeks for the teachers and YS HS and five weeks for the REU, all group members were assigned to work on an engineering research project with engineers and engineering graduate students to build their engineering research, design, and content knowledge and skills. The teachers in the RET worked as a group with a solar energy engineer and an engineering graduate student to test the reliability of various types of solar irradiance measuring devices. Generally, solar irradiance measuring devices, which measure the amount of electromagnetic radiation received from the sun in a specific area, are large and expensive. Therefore, they are not accessible to K-12 teachers and students. Thus, various groups associated with the SEER program, including teacher participants of the RET in prior summers, designed portable, inexpensive devices. However, in order to be useful, the devices also needed to be accurate and to calibrate with one of the large devices at another nearby university. The role of the teachers in Year 3 was to test the various kinds of devices to determine and compare their reliability in measuring solar irradiance. The teachers also created their own Solar Irradiance Devices, using the plans created by RET participants during prior summers, to use in their classrooms.

The REU students worked in pairs assigned to engineering faculty, engineers, or engineering graduate students to assist them with one of the mentors' solar energy engineering projects. Four of the YS HS students continued their work on a community-based engineering project - a school solar pavilion - they had begun as part of their participation in the YS MS program in Year 1. The other two YS HS students worked together on an engineering research project. The YS HS students worked with a variety of education and engineering mentors during this time. The YS MS students developed ideas for small, community-based solar energy science and engineering projects. Depending on the nature of their research projects and location of their mentors, the group members worked at either the solar laboratory or in a classroom on the university campus.

Cross-Program Events

Across the same three weeks, the RET, REU, and YS HS group members continued to interact with each other in a variety of ways. YS MS students often joined in these events if they coincided with one of the days of their program. These events included weekly lab meetings, guest speakers, and field trips. The weekly lab meetings were an opportunity for group members to come together and update the group on their research projects and progress, learn about others' projects, and share ideas for continuing to move their research forward. The teachers in the RET program also had the opportunity to share their pedagogical work and the instructional materials they were creating and get feedback from the group.

The groups also met together for guest speakers who addressed a variety of topics from innovative developments in solar panels to cultural responsiveness in science and engineering disciplines. Occasionally throughout the program, the group members also went on field trips to various locations around the university campus or in the local areas in order to learn more about how photovoltaics and solar energy are integrated into existing energy systems, and to learn more about social and technical aspects of solar energy engineering research, including its potential for having both negative and positive impacts on people's lives.

In addition to implementing RESET for the first time in Year 3, the education director and a sustainability faculty member and graduate student also implemented *Futures Thinking* activities as part of the SEER summer program. Futures Thinking consisted of six activities designed to help group members engage with thinking about solar energy specifically and other issues of sustainability in relation to possible futures. In one activity, group members designed a solar panel integration considering both its utility (e.g., producing electricity through solar energy) and its aesthetics.

In another Futures Thinking activity, group members engaged in a “Variable Worlds” game where they randomly selected (using a die or coin) possible future world conditions in terms of areas such as climate, government, and economics. Each participant then created a narrative explaining one possible way the world could have arrived at these conditions and actions that could support or change those conditions depending upon their desirability. Group members from all of the SEER sub-programs participated in the Futures Thinking activities together, including the YS MS on days when they were participating in the program. When the YS MS students could not join the full group, they participated in the same activity as a group on their next program day.

Participant Selection

Teacher Participants

The six teachers who participated in the Year 3 summer RET were selected from a pool of 12 applicants in part because they were mid-career teachers (i.e., between six to twenty years of teaching experience) of at least one STEM subject area (see Table 5). Five of the participants were classroom teachers from a range of grade levels. The other teacher, Abby, had several years of classroom teaching experience. However, at the time of the SEER RET program, she worked at the district level as a K-8 STEM professional development and outreach educator. During the first day of the program, I introduced my study to the teachers and helped to gather the participant consent forms used for all of the education research, including the RESET study, conducted as part of the SEER summer program. All six teachers consented to participate in the RESET study.

Table 5

RET Participant Information

Teacher (Pseudonym)	Years of Teaching	Grade Level	Content Area	Gender	Race/Ethnicity
Abby	12	K-8th	STEM PD	Female	White
Dean	18	2nd	All	Male	Native American
Julie	8	5th	Science	Female	White
Tom	16	6th-8th	Science	Male	White
Bianca	6	10th-12th	Anatomy & Physiology	Female	Hispanic/Latina
Fernando	13	11th	Integrated Math & Robotics	Male	Hispanic/Latino; Native American

For this study, I focused on a purposive sample of educators in elementary and middle school settings, including three teachers (i.e., Dean, Julie, Tom) and a K-8 professional development and outreach educator (i.e., Abby). I chose to focus on K-8 educators participating in the RESET PD as part of the RET program because teacher education programs traditionally have not prepared teachers to integrate engineering content or practices into their curriculum and instruction (Utley et al., 2019). This is especially true of K-8 teachers who are prepared as generalists, without a subject specialization, who often rate STEM content areas as those they feel least prepared to teach and those they like teaching the least (e.g., Denessen et al., 2015; Wilkins, 2009). This is problematic not only because of the increasing emphasis on STEM disciplines in K-12 standards and curricula, but also because evidence suggests that many elementary and middle school students decide whether or not they want to pursue STEM careers before they enter high school (Wyss et al., 2012).

Thus, it is important to prepare K-8 teachers to teach STEM content areas in a way that supports the continued interest and participation of students in STEM, and especially those students who have historically been underrepresented in STEM careers. In this study, I focused specifically on the science and engineering components of STEM, as that is the primary focus of the SEER program. However, the technology and mathematical aspects of solar energy science and engineering are a part of their engineering research work and often part of the instructional materials teachers create as well.

While five of the six teachers in the RET program self-selected into teaching STEM subjects, and all of the teachers had applied to be participants in the SEER program, they did not fall in the majority of teachers who dislike teaching STEM subjects. However, all of the teachers except Fernando reported, through their SEER application materials, group introductions, and interviews held in the first week of the program, feeling underprepared to teach engineering content and practices. Further, none of the teachers had much background knowledge or experience in solar energy science and engineering. In the following sections, I provide a brief overview of each of the teacher's educational backgrounds and prior knowledge and experiences with science and engineering instruction, solar energy knowledge and instruction, and developing curricula plans and resources. I also share teachers' reported goals for participating in the SEER program. These background statements were sent via email to each teacher to give them the opportunity to provide “member checks on the accuracy of [the] descriptions” (Miles et al., 2020, p. 51) and updated to reflect any needed changes.

Abby

Abby earned her bachelor’s degree in Environmental Science. However, she realized that many of the opportunities she had as an environmental scientist were education-related, and so she returned to school to become a certified teacher through a post-baccalaureate degree program. Over the course of her career as an educator, Abby held a variety of roles in addition to having opportunities to work at a university gaining “technical, real world [STEM] job experiences.” Abby was a high school science and special education teacher and then worked at the district level to integrate sustainability content into high school science courses. She also reported having experience developing curricula for biology and earth science courses but only “limited experience writing engineering curriculum.”

At the time of the Year 3 SEER program, Abby was a K-8 STEM PD Coordinator. She provided training and outreach activities to administrators, teachers, and students of the Title I district where she worked, which was located in a suburb near one of the largest cities in the United States. Abby was passionate about sustainability science education, and reported having “general sustainability” knowledge and experience. In her first year in the district position, she “created and led… lessons on applications using passive solar energy (such as solar cooking)” as part of her district’s Sustainability Academy for teachers. However, she had no experience with the technical aspects of solar energy (i.e., photovoltaics). Abby heard of the work that a group of students from her district was doing through the SEER program. Thus, she was very interested in being part of the SEER RET herself in order to try and expand that type of knowledge and learning with other teachers and students in the district. Specifically, Abby stated that one of her goals for participating in the SEER program included expanding “the curriculum I develop and offer to teachers [in the Sustainability Academy] and students [in after school sustainability clubs] to include basic concepts underpinning solar energy and photovoltaics.” She also reported the goal “to write lesson plans using engineering design principles and tech tools… to help the students within [the district] feel empowered to design solar photovoltaics spaces within their school communities.”

Dean

Dean had been an elementary school teacher for 18 years at the time of his participation in the SEER program. The school year prior to the SEER program, he had been a self-contained third grade classroom teacher, teaching all content areas to his students. The following school year he would be moving to teach a self-contained second grade classroom. Dean noted that, while he was responsible for teaching all content areas, his school emphasized literacy and mathematics instruction. Thus, he generally taught science content through informational texts in order to support this focus. He did report, however, having integrated a few hands-on engineering lessons into his instruction the previous year. As part of Dean’s work with other teachers and administrators at the school, he reported being “familiar” with “writing and revising” curriculum each year “based on the current trends in education.”

Dean taught at an elementary school in Navajo Nation. He was the only teacher participant during the Year 3 SEER program who did not reside in the area local to the host university. However, other teachers from Dean’s area had participated in SEER

RETs previously, and he was interested in learning more about solar energy content, something that was new to him. In sharing his goals for participation in the RET program, Dean stated, “I would like to gain experience in the field of research and apply it at the elementary level. I would like to expand my knowledge about solar energy and share it with my students.” Specifically, Dean was interested in learning about the developments in solar panels and the advantages of using solar energy at the “business and residential level.” Dean also expressed wanting to use the research skills he developed to support his students in their participating in the yearly science fair and “ask students to create a project on solar energy and its many uses in our everyday lives.”

Julie

During the eight years of her teaching career, Julie taught third through fifth grades as a generalist or science and math teacher. She also earned a master’s degree in reading. The school year following the RET, however, Julie would be moving to teach seventh and eighth grade science at the same K-8 school. Her district and school were located in another suburban area of the same large metropolitan area where five of the six teachers worked. In addition to her experience as a classroom teacher, Julie reported two experiences working with other teachers through grant-funded projects where they “broadened their own scientific understanding, developed new ways to teach hands on science in highly engaging ways, and collaborated in teams to create science units.” She had also written a second grade science curriculum, “primarily focused on the subjects of matter and ecosystems with engineering and tech standards interlaced throughout” for an educational company.

Julie reported that she did not have "much experience with solar energy" beyond having her past fourth grade students make solar ovens. Thus, Julie's switch to teaching seventh and eighth grade science courses and the state's adoption of new science standards for the following school year fueled her interest in participating in the SEER RET program. The state's new standards aligned closely with the NGSS standards (NGSS Lead States, 2013), and Julie explained that the "new standards required more in depth understanding of engineering, technical, and science reasoning along with the cross cutting concepts that are woven throughout the standards." Thus, her goal was to "gain new knowledge to help bring more meaningful STEM activities into the classroom to solve real world problems in science and develop a powerfully relevant unit based on sound scientific facts and understandings." Julie also hoped to help her students "develop an excitement for solar energy through a well thought out curricular unit that utilized hands on activities to help them make meaningful connections to concepts." Finally, Julie reported that "we are also looking at starting a STEM club at our school in hopes to inspire the love of science and create aspiring career pathways" and she felt that her participation in the RET program could help her with this goal.

Tom

Tom began his professional career in law enforcement as a police officer. After working in the schools as part of an educational program for students, though, he chose to become an educator. He had since earned master's degrees in secondary education and administration. At the time of the program, Tom had taught math and science at the middle and high school level for 15 years at two different districts situated in suburbs within the large metropolitan area. His assignment at the time of the RET was teaching sixth through eighth grade science and math in the same district where Abby worked. In addition to his teaching responsibilities, he was serving as his school's energy coach, working with teachers and students "to find ways to reduce our overall energy expenses," and "this year we have averaged a 20-25% reduction in our school's electric usage." Though Tom had "limited experience with solar" prior to the school year before his participation in the SEER RET program, he had "worked with students on solar powered cars, fans and other such items." Tom had also recently moved into a home with solar panels, and "between school and home, I have become very involved and excited about solar energy."

Tom reported that his goals for participation included bringing "energy saving measures to our students, staff, families, and community." He further explained that "our students have some great ideas and a desire to make a difference in their future. This program would help me to bring them new and fresh ideas as well as the resources to help them grow." Specifically, Tom reported feeling that he could "have a huge impact on the growth of our students by helping them to see the potential, opportunities, and overall effect that knowledge about [solar energy] can have on and for them."

Bianca and Fernando

The other two participants in the Year 3 SEER RET program, Bianca and Fernando, taught high school STEM subjects. Therefore, they were not focal participants for this study. However, because of the structure of RESET, all of the teacher participants' contributions and ideas were central to shaping the group's and individuals' learning. Therefore, I still provide background information for both Bianca and Fernando to provide context for these interactions.

Bianca was the newest of all the mid-career teachers with six years of teaching experience. After graduating with a bachelor's degree in molecular and cellular biology, she became a middle school science teacher and earned a master's degree in secondary education. Bianca taught a variety of science courses at both the middle and high school levels in two different districts during her career. The year prior to the RET, she taught an integrated science course for ninth graders at a public high school near the university and worked with other instructors to integrate more sustainability content into the course. Thus, Bianca was interested in participating in the SEER RET at the recommendation of her colleague, a participant in previous RET programs, who continued to work closely with the SEER program.

Just before the summer program began, Bianca discovered she would be teaching anatomy and physiology courses the following year. Thus, the solar energy content was no longer as applicable to her own curriculum and instruction. However, Bianca would continue to mentor and work with the teachers of the integrated science course and felt participating in the SEER would strengthen her ability to do so. She also wanted to incorporate the engineering principles into the courses she would teach.

Fernando earned a bachelor's degree in engineering, and then went on to earn a master's degree in curriculum and instruction for secondary education. During his 13 years as an educator prior to his participation in the SEER RET program, Fernando taught various courses in mathematics and physics and became National Board certified in mathematics. Fernando taught at a STEM-focused public high school located in the downtown area of a large city. He also founded and had served for many years as the robotics mentor for various clubs and competitions for students.

Fernando worked with another former RET participant who had remained engaged with the SEER program and a small group of students from his high school had participated or were participating in the SEER YS HS programs. Fernando had several goals for participating in the SEER. He explained that “I want to use this technical experience in obtaining Career Technical Elective (CTE) certification in case any CTE positions open up at my school.” He also looked forward to the opportunity to “interact with solar panel researchers.” Fernando had considered “working in the solar panel industry” upon earning his bachelor’s degree, and so he hoped “that this program will fulfil my initial dream.” In terms of his work with students, Fernando was interested in gaining “technical abilities” in addition to his “abstract skills,” as these skills were especially important in his work as a robotics coach. He also hoped to engage his advanced mathematics students in mathematically modeling “the efficiency and durability of [solar] panels.”

RESET Support Team

While this study focuses on the teachers participating in the RET and RESET intervention, the knowledge and expertise of several others was key to the implementation of RESET. I include a brief introduction of the members of this “support team” here to provide context to the descriptions of their roles in later sections.

YS MS Program Facilitator: Jade Whipple

Jade Whipple taught eighth grade science and engineering at a K-8 school in the same Title I district where Abby and Tom worked. Jade had taught for 15 years prior to the Year 3 SEER RET, and had facilitated the Mathematics, Science, and Engineering Achievement (MESA) after school club at her school for several years. Jade first engaged with the SEER program as an RET participant. She then worked with SEER's education director to develop and facilitate the six-day SEER YS MS sub-program beginning in the summer of 2017. Continuing into subsequent school years and summers, Jade mentored students from the YS MS groups in advancing their knowledge and working to further community-based engineering design projects (Jordan et al., In Press; Wakefield, Jordan, & DeLaRosa, 2018).

Jade's ongoing work as an eighth grade science teacher, MESA coach, and with SEER YS MS participants allowed ample opportunity for the SEER education director and I to observe Jade as an educator and to collaborate with her on various projects. From these experiences, we found that Jade provided an example of one way to enact the role identity of a culturally responsive science and engineering teacher. I provide an overview of Jade's role identity as related to CRT here, including her overarching beliefs about students and instruction, self-perceptions, goals, and perceived action possibilities. I provide specific examples of how she enacted this role identity during the Year 3 YS MS program in the findings chapter.

Jade consistently sought to empower her students both socially and academically through building relationships, setting high expectations, and providing needed support for all students to meet these expectations. Jade often explicitly discussed her own background as a Latina growing up in a large city and experiencing poverty. She used these experiences to connect with her students from similar backgrounds, to highlight her own and her students' assets from their cultures and experiences, and to teach students possible ways to "navigate the system" in order to achieve the academic and social success of which she knew they were capable. Jade's main classroom "rule" was that everyone must ensure their own and others' physical, mental, and emotional safety at all times. Jade trusted her students to monitor their social and academic behavior within her high expectations and allowed for flexibility in meeting expectations through diversified instruction, curricula, and classroom policies that focused on supporting students' learning, growth, and self-regulation. Additionally, Jade provided many opportunities for students to demonstrate their learning in a variety of ways and to select topics and projects that were meaningful to them and to their communities.

Finally, Jade consistently and explicitly addressed alternative perspectives and viewpoints and advocated for students' engagement in disrupting inequitable systems and practices. She recognized that her students did not lack the abilities or drive to succeed in science and engineering but had often been denied needed access and resources based on where they lived or their racial, cultural, or ethnic backgrounds. Therefore, she advocated for opportunities such as the SEER program, wrote grants for materials and experiences, taught her students how to advocate for themselves and provided them opportunities to share their work in as many arenas as possible. Jade had consistently been recognized by students, parents, administrators, and other stakeholders as a highly effective educator who cares deeply about her students and who works to define and ensure students' success in a variety of ways.

YS MS Students

The ten students who participated in the Year 3 SEER YS MS program were recruited from the Title I district where Jade taught. All but two of the students had previously been students of Jade's who showed an interest in continuing to pursue science and engineering in their schooling and possibly as a career. Because these students were not focal participants in this study, but rather participated in an observable example of CRT and as experts in what they found to be responsive teaching, they are described as a group through the manuscript. When individual students are quoted, no individually identifying information is provided.

Because this is a summer program, students are described in terms of the grade level they would be entering in the fall. Nine of the students would be seventh through ninth graders during the next school year. The tenth student, who would be a tenth grade student the following school year, had participated in the YS MS the previous summer. Though she participated in the activities, her primary role was to be Jade's assistant and a mentor to the new YS MS participants. Most of the students identified their racial or ethnic background as Hispanic or Latinx, with a small number of students identifying as White. Seven of the students identified as female and three as male.

Guest Presenter: Kesia Adisa

One of the presenters during the SEER summer program, Dr. Kesia Adisa (pseudonym), was asked to specifically address CRT. The RET, REU, and YS HS students attended this presentation. Dr. Adisa was the Director of Equity and Inclusion for a suburban district near the university. She provided training and mentoring in equity, culturally responsive instruction, and diversity for educators in her district and nationwide as she worked to ensure educational opportunities and success for all students. She was born in Sierra Leone, and grew up in the US.

SEER Program Education Director: Michelle Jordan

Dr. Jordan, an associate professor in the university's teacher college, was the education director of the SEER Program. In this role, she was the primary designer and facilitator of the SEER program each summer. She coordinated with other program directors to ensure each sub-program's group members would have engineering mentors to work with. She also provided training to the engineers and engineering graduate students in effective mentoring strategies. Before becoming a university professor, Dr. Jordan was a mid-career K-8 teacher.

Research Design

Design-Based Research

Given the background, context, and participants of the SEER summer program generally, and the Year 3 SEER program specifically, I next describe my choice of design based research (DBR) as the overarching methodological framework guiding this study as well as continued research on the RET program and the RESET PD specifically (Bakker, 2018). McKenney and Reeves (2019), who included DBR as one type of educational design research, portrayed design research as theoretically oriented, interventionist, collaborative, responsively grounded, and iterative. This study aligned with each of these characteristics of DBR, as described in the following sections.

Theoretically Oriented and Interventionist

The SEER summer program was guided by a set of overarching expectations determined by the National Science Foundation in regards to research experiences (NSF, 2017), as detailed in the previous chapter. However, the directors of the program set the specific aims of the program and directors and facilitators designed the sub-programs and experiences within this frame to achieve these aims. In the case of the RESET PD intervention, embedded within the RET program, the specific goal was to support mid-career K-8 teachers' development as culturally responsive science and engineering teachers. While there was research support for various components of this aim (e.g., culturally responsive pedagogies, science and engineering in K-8, teacher professional development), there was a scarcity of empirically-based research on integrating all of these areas together, and therefore, a lack of naturalistic models to study. Thus, I utilized a design-based research (DBR) approach to develop the RESET PD intervention based on the extensive theoretical scholarship on culturally responsive (and related) pedagogies, as well as on the need for more equitable access to STEM disciplines for students who are historically underserved and underrepresented.

Collaborative and Responsively Grounded

Another major focus of DBR is the intertwining of design, research, and theory development (Bakker, 2018). The SEER educational team, which included the education director and up to five education graduate students including myself (i.e., five in Year 1; two in Year 2 and Year 3) in collaboration with past RET participants, study what happens in the program each summer for practical, utility-oriented reasons: to improve the program, to support teachers' integration of science and engineering practices into their classrooms, and to foster students' interest in STEM fields. We also, though, aim to contribute to the scholarship and theoretical understanding of topics such as uncertainty, professional development, engineering education, youth participation in meaningful projects, and teachers' learning trajectories and identities.

While major shifts in the program design or added components are generally only added between each summer's iteration of the SEER program, other smaller shifts are made frequently during the summer program. Throughout the SEER program, the education research team solicits ongoing reflection and feedback on group members' experiences. We use this feedback to adapt the program design in response to participant needs (e.g., additional content instruction), interests (e.g., residential solar panel systems), constraints (e.g., malfunctioning laboratory equipment), challenges (e.g., illness), and time-sensitive opportunities (e.g., a new field trip).

Iterative

DBR is also iterative, with the intervention evolving over time (McKenney & Reeves, 2019). The SEER program includes multiple sub-programs, and multiple activities and aims within and across these sub-programs, all of which go through a process of design, iteration, and evaluation each year. In this study, I focus on one specific iteration of the pedagogical portion of the RET program during the summer of Year 3. The RESET PD intervention was built on previous iterations of the RET's pedagogical focus, and adapted versions will be used in future iterations, based on the findings of this study.

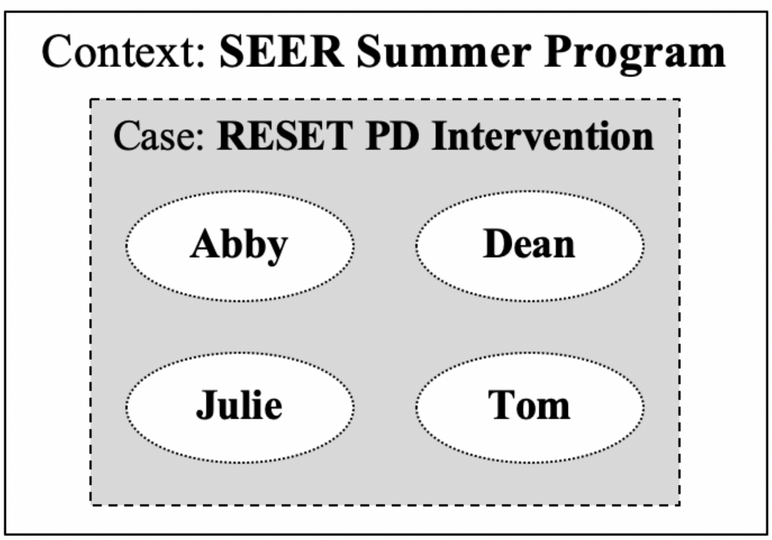
Case Study Methodology

Bakker (2018) explained that DBR does not have one specific set of prescribed methodologies or methods. Rather, DBR is a "genre of flexibly using research approaches for the purpose of gaining design based insights and research-based designs" (p. 7). Thus, researchers using DBR select the research approaches and methods that allow them to explore their designs for practical and theoretical purposes. Further, data collection and analysis in DBR focus not only on participants' learning but also on how the learning is generated and supported (Cobb et al., 2003). Similarly, Yin (2009) explained that case study research is useful for describing possible links between complex interventions in real-life contexts, such as the RESET PD, and outcomes.

Thus, while DBR serves as the overarching methodological framework for this research, I also used case study methodology to investigate the Year 3 iteration of RESET. Specifically, I used an embedded, single-case design (Yin, 2018). The RESET PD designed intervention was the focal case and the four K-8 teachers as the embedded units of analysis (see Figure 3). This design allowed me to focus on the influences of this iteration of RESET not only through studying its design and implementation, but also through exploring the trajectories, experiences, role identities and actions of four of the participant teachers. These teachers were considered as embedded units of analysis rather than as their own cases (e.g., multiple-case design) because their experiences primarily served to enhance understanding of the RESET PD.

Figure 3

RESET's Embedded Single-Case Design



Note. Adapted from Yin's (2018) Type 2 design for case studies (p. 47).

The "case" of the Year 3 RESET PD intervention is described in the following sections with the detail commonly expected from a DBR study. DBR researchers aim to "provide a trustworthy account whereby a series of events—each of which is local and contingent—can be seen as part of an emergent and potentially reproducible pattern" (Cobb et al., 2003, p. 12). This involved producing a detailed narrative with rich descriptions of the context of the study, the theory or theories that guided the development of the intervention, and the innovation's design features (Barab & Squire, 2004). It also included justifying initial designs and decisions (Cobb et al.; Hoadley, 2004; McKenney & Reeves, 2019).

Designing the RESET PD Intervention

My own trajectory within the SEER program began in the summer of Year 1. I worked as a graduate research assistant to the SEER education director and primarily helped to collect and organize data across the four SEER sub-programs. Given my own background as an educator, I also served as an education mentor in the RET program, providing support and feedback to teachers about the lessons and instructional materials they created and facilitating a pedagogical workshop on the Next Generation Science Standards (NGSS) and related state standards for participating teachers.

Following the summer program, I worked closely with the SEER education director and other graduate students to research and evaluate the Year 1 iteration of the SEER program, and specifically the RET. We focused on the overall design of the RET and the affordances and constraints of engaging the teachers both in engineering research projects and creating instructional plans and materials during the program (e.g., Wakefield, Bowers, et al., 2018). I also collaborated with the education director and Jade as we studied one of the key aspects of the Year 1 SEER program design: situating the group members from all four sub-programs as both learners and contributors to important science and engineering work. We especially focused on how this positioning influenced the experiences of the YS MS (Wakefield, Jordan, & DeLaRosa, 2018).

As we prepared for the Year 2 iteration of the SEER program, I continued to work closely with the education director to help plan program events and activities based on what we had learned about the program through our research work. To build on and extend the work of our first RET iteration, for example, the educational team sought to integrate an explicit focus on what the types of experiences and learning they were doing in the summer program could look like in K-12 classrooms. Thus, in the Year 2 RET, we brought back four of the participants from the RET the previous summer to serve as mentors for the new teacher participants in both their engineering research project and their curricula design. We knew these teachers could share their classroom experiences with implementing what they had learned in the RET program the prior summer and how they navigated some of the constraints and challenges of this implementation. While my role as a graduate research assistant and education mentor included the same responsibilities as the previous summer, I also helped to facilitate the logistics of the full program. Throughout the school year following the Year 2 SEER program, I again joined others in studying, learning from, and improving the program as well as in presenting our work to others (e.g., Wakefield, 2019; Wakefield & Jordan, 2019). In several aspects of my research agenda during this time, I also became increasingly focused on designing professional development opportunities for teachers in ways that supported their agentive actions (Priestley et al., 2015) and various role identities (Garner & Kaplan, 2019) as teachers.

In planning the Year 3 SEER RET program, the education director and I knew we wanted to sharpen our focus on one of the aims of the pedagogical component of the RET. We wanted to help teachers develop curricula materials and pedagogical strategies that engaged their students in science and engineering in meaningful ways and that encouraged students, especially those historically underrepresented and underserved in STEM classes, degree programs, and careers, to not only persist in STEM, but also to contribute in ways that rely on their community and cultural knowledge.

Our work together the past two years allowed us to explore and learn from the work the YS MS and YS HS group members were doing both during and after their participation in the SEER program. Because we wanted to focus on how teachers' could engage students in science and engineering projects that were largely student-driven and meaningful to the students in their classes, I proposed to the education director that we use CRT (Gay, 2018) as the guiding framework for the pedagogical component of the Year 3 SEER RET. She agreed, and this study and the RESET PD intervention grew out of that focus.

Conjecture Mapping

As discussed in the review of the literature related to DBR, conjecture mapping provides a framework for representing the design of an intervention and for tracking adaptations and iterations of the design (Sandoval, 2014). Specifically, a conjecture map shows hypothesized relationships between design features, processes, and outcomes (Boelens et al., 2020). Thus, one of the first steps I undertook as part of designing RESET was creating a conjecture map. The initial conjecture map for the RESET included Sandoval's (2014) process and terminology for conjecture mapping. I later updated the conjecture map to reflect elements of Boelen and colleagues' (2020) adapted conjecture mapping process to increase clarity, especially in regards to terminology. RESET Conjecture Map 1 (see Appendix A) reflected the plan for RESET's implementation before the beginning of the Year 3 SEER RET program.

The design of RESET began with a *high-level conjecture* or general, theory-based idea for supporting a desired form of learning (Sandoval, 2014). Through the high-level conjecture for this study, I hypothesized:

> Integrating a focus on the principles of CRT as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

From this high-level conjecture, I began to develop the characteristics and components of the RESET design, or the design features (Boelens et al., 2020). These components are introduced here and discussed in detail in the next section.

According to Boelens and colleagues (2020), *design features* included materials and resources, activity and task structures, and participation and practices. *Materials and resources* referred to any physical artifacts provided to participants to use in the intervention. In RESET, these materials included digital and physical resources (e.g., journal articles, presentation slides, example lesson plans) related to CRT and to science and engineering standards and pedagogical strategies.

Activities and task structures contained the key events of the intervention. In RESET, this included the introductions and community-building activities between the teachers and YS MS students. The other four key activities in RESET consisted of attending a guest lecture about CRT, observing and interacting with Jade Whipple and the YS MS students in their learning activities, finding connections between teachers' own engineering research and design work and their classroom instruction, and participating in short workshops focused on pedagogical strategies that have shown promise for culturally responsive science and engineering teaching. The task structure that cut across the RESET PD was providing opportunities and time for teachers to engage in critical reflection and discussion of each of the key activities.

The *participation and practices* component of the design features includes expectations for participants' engagement during the activities and tasks (Boelens et al., 2020). Across the SEER program, one of the foundational expectations and beliefs was that every group member from each of the four sub-programs was both a learner and a contributor to others' learning (Wakefield, Jordan, & DeLaRosa, 2018). Thus, this expectation was integrated into the RESET PD as well. Specific to RESET was the expectation that the teachers would engage in discussions about all of the experiences, pedagogical practices, and solar energy content they engaged with through a critical lens and centered on CRT.

After determining the design features of RESET, I continued the conjecture mapping process and developed the design conjectures for the study. Through *design conjectures,* researchers hypothesize how the design features of the intervention will generate specific processes (Boelens et al., 2020; Sandoval, 2014). In the case of RESET, I developed this overarching design conjecture:

> If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum.

The design conjecture connects the design features to the *enactment processes*. Sandoval's (2014) conjecture mapping process included one, overarching design conjecture, while Boelens and colleagues (2020) chose to develop a design conjecture for each connection between an enactment process and design feature. I choose to do both overarching and specific design conjectures. However, the specific design conjectures will be introduced and discussed in Chapter 5.

Both Sandoval (2014) and Boelens et al. (2020) represented these targeted connections and conjectures with arrows on their conjecture maps. In order to increase the readability and clarity of the RESET conjecture maps, I chose to note the targeted connections between design features, enactment processes, and outcomes with corresponding letters and numbers in text boxes. For example, in RESET, the first design feature is CRT resources. The use of these resources was designed to support teachers' creation of responsive science and engineering curricula (Enactment Process A) and to help teachers feel empowered to enact CRT with their students (Enactment Process F). Thus, on RESET Conjecture Map 1, the letters A and F are next to the first design feature.

Sandoval (2014), who referred to *enactment processes* as *meditating processes*, included the artifacts participants created and their observable interactions. Boelens and colleagues (2020) added a third component: participant experiences. Through participation in RESET, the teachers created one main *participant artifact*: curriculum, or instructional plans and materials to help them implement a solar energy focused science and engineering lesson in their classrooms during the following school year. The focal *observable actions* that were generated by RESET's design features included critically evaluating key events through group discussions, consultations related to the curriculum teachers created, and the range of interactions between the RET participants and other participants. In terms of *participant experiences*, RESET was designed to allow teachers to experience a responsive learning environment themselves as well as to see examples of responsive environments with students. Additionally, RESET was designed to foster a feeling of empowerment amongst the teachers as they became more aware of beliefs, practices, and action possibilities related to culturally responsive science and engineering teaching.

As the next step in conjecture mapping, the *process conjecture* ties the enactment processes to the targeted outcomes through stating why (Boelens et al., 2020) these processes should result in the outcomes. As with the design conjectures, Sandoval (2014) included just one overarching process conjecture and Boelens et al. (2020) included specific process conjectures. Again, I chose to include both, but will detail the specific process conjectures in Chapter 5, though you can see the targeted outcomes for each enactment process in text boxes between these two columns on the conjecture map. I developed this overarching process conjecture for RESET:

> If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally responsive science and engineering teaching in their classrooms.

Thus, RESET was designed to target three main *outcomes*. First, I sought to design a PD that supported teachers in developing or strengthening a role identity as a culturally responsive science and engineering teacher. Second, teachers integrate CRT principles into their science and engineering instructional practices the following school year. Finally, teachers would engage in actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines.

As a final note regarding my creation of RESET conjecture maps, in order to be succinct, I only included the one or two primary targeted connections between design features, enactment processes, and outcomes. I recognized that there were likely additional connections between features, processes, and outcomes and that some may influence each other reciprocally (Boelens et al., 2020). However, a complete analysis of all possible connections and relationships between each aspect of the RESET PD design was beyond the scope of this dissertation study.

Preparing for RESET

Once I had created a conjecture map overview of the RESET PD design, I moved forward with detailed planning of how the RESET design could be enacted within the Year 3 SEER RET. Throughout the process of conjecture mapping and preparing, I worked closely with the SEER education director, Dr. Jordan. Because this was a design-based research study, I needed to ensure that the planned intervention supported the goals of the SEER RET, fit well within the structure of the Year 3 SEER summer program, and was approved by appropriate program personnel.

Once the preliminary design and goals of RESET were approved, the Dr. Jordan and I discussed the plan for RESET with Jade to solicit her feedback as a classroom teacher, the facilitator of the YS MS program, and a research collaborator. We also asked Jade if she would be willing to serve as a model of one possible way to enact CRT in science and engineering, and she agreed. It was at this point in the process that I also selected or developed measures as needed for the study and as detailed in the data collection section later in the chapter. All educational research conducted as part of the SEER program each year was submitted together to the university's Institutional Review Board (IRB). Thus, the details of my study and copies of the measures I planned to use were included in this submission and approved (see Appendix B).

Implementing RESET

The RESET PD intervention consisted of two main phases, which occurred during the Year 3 SEER RET program. In the first phase, teachers engaged in introductory activities and community-building activities designed to help them get to know each other and the YS MS students and to become familiar with the pedagogical work they would be doing as part of RESET. In the second phase, teachers participated in a variety of activities and tasks related to science and engineering research, design, and instruction. After each event, they engaged in structured reflective and discursive routines, designed to provide teachers with an opportunity to critique the experiences, examples, strategies, and standards with which they had engaged. The timeline and overview of the RESET PD intervention as it took place in the Year 3 SEER RET is presented in Table 6 and detailed in the following sections.

Table 6

RESET PD Key Event Timeline

Date	Activity or Task Structure
May 29-30	RESET study introduced Telling Identities & Community Building: Teachers and Wendy
June 6	Introductions: Teachers, Jade Whipple, and YS MS students Community Building: Positioning teachers and students as learners and contributors
June 11-12	Workshop: Introduction to CRT and intersectionality Workshop: Creating curricula and new state science standards Community Building: Telling identities prompts
June 12	CRT Guest Presenter: *Cultural Competency* by Dr. Kesia Adisa *Cultural Competency* Reflection: Individual teachers *Cultural Competency* Discussion: Teachers
June 14	CRT Example 1: Jade's work with the YS MS students
June 17	CRT Example 1 Reflection: Individual teachers' written reflections CRT Example 1 Discussion: Teachers Workshop: Funds of knowledge in engineering design
June 19	CRT Example 1 Discussion: Teachers and Jade
June 21	CRT Example 2: Jade's work with the YS MS students Students' Perspectives Discussion: Teachers and YS MS Students
June 24	CRT Example 2 and Student Perspectives Reflection: Individual teachers CRT Example 2 Discussion: Teachers CRT Example 2 Discussion: Teachers and Jade
June 26	Workshop: Productive Failure and Engineering Design and Research Processes

Introductory and Community-Building Activities

On the first day of the SEER program, Dr. Jordan and I explained our research to the participants and asked if they would be willing to participate in our studies. All six teachers completed the consent form (see Appendix C), agreeing to participate in the studies. For the first two weeks of the program, the six teachers participated with group members from other SEER sub-programs in orientation and solar energy knowledge development through Solar Cell 101. Thus, only two RESET-related activities were planned during this time. The teachers participated in the two activities to help them get to know each other, Jade, the YS MS students, and me. On the second day of the SEER program, I met with the six teachers as they waited to tour the solar cell fabrication clean room laboratory. I introduced myself to the teachers through narratives, or "telling identities" (Sfard & Prusak, 2005, p. 14), where I not only highlighted several aspects of my sociocultural and professional educator identity but also how they had evolved over time. As discussed in Chapter 2, Sfard and Prusak (2005) viewed identities as stories or "words that are taken seriously and that shape one's actions" (p. 21). So, from the beginning of the program, I wanted to model sharing stories as a way to help teachers and I get to know each other and a way for teachers to get to know students, a key component of CRT. I also hoped to connect with the teachers through our experiences as mid-career K-12 teachers.

After my introduction, and to ease teachers into the process of telling identities, I engaged teachers in a semi-structured 3-2-1 activity for their initial introductions. Teachers were given time to think of and note three specific things they were really proud of in their teaching practice, two things they would like to improve or expand on in their teaching practice, and one interesting or surprising thing about them (either professionally or personally). They then had the option to share any part or all of these things with the group. Throughout the rest of the RESET PD activities across the program, I included "telling identities" prompts and opportunities for teachers to share aspects of their own sociocultural and professional identities. Through these activities, I emphasized teachers' sharing, to the extent they were comfortable doing so, who they were personally and professionally and who they wanted to be (Beijaard, 2019), especially as related to their role identity (Kaplan & Garner, 2017) as culturally responsive science and engineering teachers.

Then, on June 6, the teachers and YS MS students interacted for the first time during a joint lunch and solar energy activities. Dr. Jordan, Jade, and I purposefully designed the introductions and activities to help both groups get to know each other and to begin to build a sense of community and shared purpose between them. We aimed to situate both groups as not only learners but also contributors in the SEER program. By focusing on all group members' learning and contributions to the learning of others, we hoped to disrupt traditional hierarchical roles of teachers and students. These interactions were also intended to model a responsive learning environment where knowledge of each other's strengths and goals was a priority.

Dr. Jordan and Jade briefly introduced each group and our focus on everyone as learners and contributors. The teachers and the YS MS students then sat in mixed groups at the lunch tables and introduced themselves as they ate. We especially encouraged them to talk about their experiences so far in science and engineering and the types of projects they had or were hoping to engage in through the program. For example, two of the YS

MS participants had worked throughout the school year with a group of YS MS students from the previous summer in moving forward their water purification education project. Others had participated in the MESA club with Jade or at other schools. The teachers shared the work they were doing fabricating solar cells in the laboratory and any previous experience with solar energy or engineering. At the end of lunchtime, teachers and students shared with the group what they had learned about each other.

After lunch, the teachers and students were divided into two groups to participate in solar energy science or engineering activities created by previous teacher participants in the RET. In one activity, the teachers were able to support students through a simulation of how solar panels are created in the laboratory, based on their experiences working in the laboratory. Students then gave feedback about what they had learned and how the activity and presentation could be improved as teachers implemented it with the students in their classrooms. In the other activity, the teachers and students participated together in a demonstration of the impact of differing temperatures on solar panels. The groups then switched so that all were able to participate in both activities. In the first conjecture map, I had included the SEER program focus on engagement as learners and contributors in two places in the design features column. In the second conjecture map, I combined them into a since feature in the participation and practices section. This adaptation is reflected in *RESET Conjecture Map 2* (see Appendix D).

Pedagogical Activities

During the third through fifth weeks of the RET program, teachers split their time between working on their engineering research and design project with a solar energy engineer and engineering graduate student and engaging in the pedagogical workshops and creating curricula (which generally consisted of lesson or unit plans and needed materials, such as slide decks, examples, learning activities) they could use in their classrooms as part of the RESET PD intervention. On Mondays, Wednesdays, and Fridays, teachers engaged in pedagogical work and participated in cross-program activities with the members of other sub-groups on the university campus. When teachers were not participating in RESET key events, they worked on their instructional materials with the support, as needed, of other teachers, Dr. Jordan, and I. Originally, Dr. Jordan and I had planned to hold formal curriculum consultations with each teacher during RESET, as we had in previous iterations of the RET. During these consultations, Dr. Jordan or I would meet with each teacher individually and discuss their curriculum, ask questions, answer questions, help them find needed resources, and so on. However, in this iteration, the teachers enjoyed sharing their curricula work with the whole group and getting feedback that way. Therefore, on the updated version of the conjecture map, these informal curricula conversations were grouped into the enactment process of interactions with others.

On Tuesdays and Thursdays, the teachers worked on their engineering project at the solar energy laboratories with their engineering mentors. The majority of the RESET implementation and data collection efforts took place in the pedagogical component of the RET. However, part of the original design of RESET was to provide teachers opportunities to critically reflect on and discuss their ongoing science and engineering experiences in Solar Cell 101 and in their research project and other activities. However, once we began the program, I realized that we would not have the time to engage in deep reflection and discussion about each of the events and activities teachers participated in throughout the RET program. Because the teachers had opportunities to discuss their science and engineering work in laboratory meetings and as part of the instructional materials they were creating, I adapted the RESET design to focus teachers' reflection and discussion mainly on the culturally responsive examples and pedagogical workshops. I also sought to facilitate and highlight the teachers' connections to their own science and engineering experiences in each workshop, example, reflection, and discussion. This mid-program adaptation to the RESET design is also reflected in *RESET Conjecture Map 2*.

Pedagogical Workshops

The pedagogical workshops, which were also included in the Year 1 and 2 iterations of the RET program, were designed to (re)introduce the teachers to three research-based instructional approaches that had shown promise for engaging students in meaningful science and engineering learning: productive failure (Kapur, 2008); interactive, constructive, active, and passive activities (ICAP; Meneske et al., 2013); and engineering design projects (Moore et al., 2014). We also conducted one workshop on the science and engineering standards adopted by the state where the teachers taught, which were closely related to NGSS (Bybee, 2011; NGSS Lead States, 2013). Before or during each workshop, teachers would read an article detailing the pedagogical approach or standards. Then, an education mentor would engage the teachers in a discussion about the article and the approach or standards, focusing on the possibilities for integrating it into the teachers' instructional plans and practices along with concerns or constraints they foresaw to implementation. The ultimate purpose of the workshops was to provide resources for developing their solar energy engineering curricula plans and materials and to facilitate the transfer of these approaches into the teachers' classroom instruction.

Teachers from previous iterations of the RET had reported the workshops to be useful in both their curricula creation and implementation.

While planning the RESET PD, Dr. Jordan and I found that each of the three pedagogical approaches we had highlighted in the previous RET programs also aligned well with the principles of culturally responsive science and engineering instruction. I also wanted to include two additional pedagogical approaches specifically addressing culturally responsive science and engineering instruction: students' engineering funds of knowledge (Sias et al., 2016) and using critical literacies in engineering instruction and critiques (Wilson-Lopez et al., 2017). I knew we likely would not have time for all five workshops, but I wanted to be able to choose from a variety of topics and approaches based on the strengths, needs, and backgrounds of the teacher participants. I facilitated all of the workshops during the Year 3 RESET PD.

In our first workshop during the RESET PD, the teachers and I explored the basic principles of CRT together (Gay, 2018; see also Chapter 2). In a second workshop, we explored the state standards which had been adopted and would be implemented by the teachers the following school year. Across the remainder of our time in RESET, the teachers and I engaged with two additional pedagogical strategies: students' engineering funds of knowledge (Sias et al, 2016) and productive failure (Kapur, 2008). This adaptation was made due to the many events that the teachers had the opportunity to participate in as part of the SEER program and due to the types of engineering projects the teachers had chosen to create.

Engineering Funds of Knowledge. Moll and colleagues (1992) introduced the concept of students' *funds of knowledge* as the skills and knowledge students developed through their interactions with their family, community members, and peers. Students benefit when teachers view these funds of knowledge as assets to students learning and build on what students already know and can do. As Sias et al. (2016) noted, “Although all students can benefit when teachers draw from their everyday experiences, this instructional approach is especially beneficial for youth who have been historically underrepresented in engineering” (p. 30). Students’ funds of knowledge related to their families, communities, and recreation (e.g., digital technologies) were especially applicable to their engineering design work (Wilson-Lopez et al., 2016).

During this pedagogical workshop, we not only discussed this pedagogical approach, but also looked at examples of students’ funds of knowledge that could be built into the solar energy science and engineering curricula the teachers were creating. Before the SEER summer program began, I sent teachers an inventory created by Sias and colleagues (2016; see Appendix E) to have some or all of their students complete before the school year ended. While not all of the teachers were able to bring completed inventories, we used some of the examples from the teachers who had them during the workshop. Having student samples (with no identifying information) from teachers’ students allowed us to discuss specific ways teachers could integrate students’ funds of knowledge into their curricula plans and materials. We also discussed how to use the inventories completed by their students the following year to adapt their curricula to be responsive to those students’ funds of knowledge.

Productive Failure. Through introducing the pedagogical approach of *productive failure* (Kapur, 2008), I sought to help teachers navigate the challenge of supporting their students’ engagement in engineering design activities, which are inherently uncertain, failure-prone activities (Jordan, 2015). As a pedagogical approach, *productive failure* activities engaged students “in solving complex, ill-structured problems without the provision of support structures” (Kapur, 2008, p. 379) beyond their own and group members’ background knowledge and assets. These activities involved two stages: students’ collective engagement in a complex novel problem (i.e., generation and exploration) followed by a teacher’s explicit content-related instruction (i.e., consolidation and knowledge assembly). In other words, teachers presented groups of students with a challenging, but engaging, complex problem to solve. The teacher delayed providing instructional support to students as they solved the problem, “in order for learners to generate conceptions, representations, and understandings, even though such understandings may not initially be correct” (Kapur & Bielaczyc, 2012, p.48). Engaging in this process “prior to instruction [helped] students learn better from the instruction” (Kapur, 2016, p. 292) and facilitated the transfer of the students’ learning to solving new problems.

CRT Examples

A common critique of PD generally is the lack of real-world examples to help teachers’ envision and enact the pedagogical practices being targeted. There is no one “exemplar” of what CRT should look like in each classroom, as responsive teaching must respond to the students in the classroom at that time (Gay, 2013). However, I wanted to include an example of one possible way culturally responsive science and engineering instruction could be integrated into a classroom setting. As part of the SEER YS MS program took place in a classroom-like setting with Jade Whipple as the instructor, it was possible for me to include an example as part of RESET. Jade and I had planned for the teachers to observe and participate in the YS MS classroom activities on two separate occasions.

Both example sessions were held at the beginning of a Friday, when the YS MS group would arrive at the university. The teachers and I would visit their classroom in the building next to the ERC, where we were working. We would first observe Jade as she introduced the focus for the day. Then, Jade engaged the teachers and the students in activities related to that focus. During the first week, teachers and students engaged in shared planning and reflecting on the whiteboards around the room and worked to create a circuit using copper tape, batteries, and LED lights. During the second week, teachers and students engaged in shared reflection about problems they would like to solve in the future with what they were learning. The activities the teachers observed and participated in had been part of the YS MS each year. The main adaptation Jade made as part of RESET was to include the teachers in the activities and to position both the teachers and students as both learners and contributors to each other's learning. For example, when the teachers and their student partners were working on the whiteboards, they all shared ideas, but the students were responsible to actually write on the boards. The teachers and I generally stayed between an hour to an hour and a half until one or both groups needed to be at their next activity.

CRT Guest Presenter

As part of the RESET PD, I wanted the teachers to have access to a wide variety of perspectives on CRT and advocating for diverse students' increased access to and success in formal educational settings. As part of her role as Equity and Inclusion Director for a local school district, Dr. Kesia Adisa frequently provided this type of training for teachers and was familiar with common perceived or actual constraints to more equitable, inclusive teaching in school and how to navigate them. Thus, we invited Dr. Adisa to share her expertise with the teachers and other SEER group members as a guest presenter, and she graciously accepted. She titled the presentation, "Cultural Competency: Using Storytelling and Counter-Storytelling within the Framework of Teaching and Learning." Dr. Adisa focused on the importance of teachers' self-knowledge to knowing and responding to their students, as teachers' narratives shape their teaching and often mask biases. She then discussed a variety of common educational practices that undermine students' equitable access to learning, such as "sanitizing historical facts" and creating an environment where culturally, racially, and ability-diverse students do not see themselves reflected in "curriculum, books, or adults" around them. Dr. Adisa then discussed several ideas for promoting CRT, including the intentional use of "counter-stories, expressing high expectations for students, noticing bias in learning materials, and fostering conversations about equity concerns." The presentation lasted approximately an hour, with time for questions afterwards.

Reflections and Discussions

A central feature of the RESET PD intervention was building in time after each of the key events for teachers to critically reflect on and discuss the example, experience, or workshop in which they participated. The purpose of these reflections and discussions was to allow teachers to consider and critically engage with both the cultural responsiveness and science and engineering instructional aspects of the event or resource. Further, these reflections and discussions were designed to allow teachers to question, resist, express concerns, imagine, adapt, or expand on these ideas and perspectives as part of their role identity as culturally responsive science and engineering teachers.

Sometime after each key RESET event, teachers completed an individual, written reflection on their experiences, thoughts, and learning. These reflections were completed by each teacher in a Google Document that was also shared with me. I provided teachers with a variety of questions or prompts to choose from to guide their reflections (see Appendix F), though they were not required to use these prompts. The individual reflection time was designed to allow teachers to explore and think about their own experiences before engaging in discussion with others about the event.

Once teachers had completed their individual reflections, I would begin the discussions with an open invitation for teachers to share any thoughts they had during the event or their reflection. Throughout the discussions, I sought to minimize my role as facilitator through sitting at the table with the teachers and inviting them to respond directly to each other. Occasionally I would comment to seek clarification about a comment from a teacher, to revisit a question or concern raised by a teacher that had not been addressed by the group, to share experiences from my own personal and teaching experiences as relevant to the conversation, and to ensure that all of the teachers had the opportunity to share their ideas.

Finally, I built in time during RESET for the teachers to meet with Jade after each of the classroom visits to discuss what they had observed and any questions they had for her. Often, we began these conversations with questions that arose during our group discussions. Jade also had the opportunity during these discussions to highlight aspects of her instructional practice during the school year. During our first discussion with Jade, the teachers asked some questions about the students that Jade felt should be answered by the students. The teachers agreed. Therefore, we adapted our plan for the following week to allow for an additional discussion with the YS MS students.

Data Collection and Analysis

Throughout the summer Year 3 SEER program, the research team and I collected audio and video data from teachers' activities. For the purposes of this study, and as is common in both DBR and case study approaches (Bakker, 2018; Yin, 2018), I focused on several of these sources of data: semi-structured interviews, surveys, discussions, written reflections, artifacts, observations, researcher field notes and memos, and conjecture maps. Other observational data collected during the summer RET program was used to support analysis where more evidence, clarification, or context was needed.

As per the university's information security procedures, all of the audio, photo, and video data collected as part of the SEER summer program was uploaded to a secure folder through our university Dropbox accounts. Only the research team had access to this data. After the program, I copied all of the data related to RESET to a secure folder on my university Google Drive, another platform approved by the university for securing information. The education director was the only other person with access to this data. This Google Drive folder also housed the data sources shared with me by the teachers, including their written reflections, survey responses, and curricula materials, as well as the conjecture maps, notes, and memos I generated throughout the program.

I analyzed each of the data sources using various types of qualitative coding processes (e.g., Decuir-Gunby et al., 2011; Saldaña, 2016), matrix analysis procedures (Miles et al., 2020) and conjecture map analyses (Boelens et al., 2020). Each data source and analysis method is listed in Table 7 and explained in detail in the following sections according to when they were collected: during the summer RESET PD intervention, during the following school year, or ongoing across the full program. These methods were used to (1) explore potential relationships between teachers' participation in the RESET PD and changes in their culturally responsive science and engineering teacher role identity and instructional practices over time; (2) discern in what ways, specifically, RESET PD features supported this professional growth; and (3) test conjectures and present a design framework to guide the design of similar PD interventions.

Table 7

Data Collection and Analysis Matrix

Research Question	Source(s)	Collection	Analysis
RQ 1: How does integrating a focus on culturally responsive teaching into a designed PD intervention - through critical discussions of experiences, examples, and pedagogical strategies - influence mid-career K-8 teachers': a: Role identity development as culturally responsive science and engineering teachers? b: Science and engineering curriculum development, instructional practice and actions as advocates and agents of students' equitable access to and participation in science and engineering?	Intersectional Competency Measure Subset A	Pre: First week of RET Post: Last week of RET Google Forms	Matrix Analysis (Pre to Post)
	Semi-structured Individual Interviews: Initial, Exit, and Final	Initial: First week of RET Exit: Last week of RET Final: School year Audio recorded & transcribed	Cycles of Qualitative Data Coding Within and Cross-Case Analysis
	Individual Reflections	After key RESET events Shared Google Document	
	Group Discussions (RET, Jade, YS MS)	After key RESET events Audio/video recorded & transcribed	
	Teachers' Designed Curricula Materials	Last day of the RET Shared via Google Drive folders	
	Classroom Observations	School year Researcher field notes	
	Follow Up Survey	School Year Google Forms survey	

	Implementation Artifacts	School year Emails, photos	As needed to support analysis
Research Question	**Source(s)**	**Collection**	**Analysis**
2) What do we learn about how to integrate a focus on culturally responsive teaching as an inherent part of a science and engineering PD?	Semi-structured interviews: Exit and Final	Individual teachers Exit: Last week of RET Final: School year Audio recorded & transcribed	RQ 1 Analysis Cross-Case Analysis
	Conjecture Maps	Initial: Blueprint for RESET Subsequent: Reflect adaptations	Conjecture Map Analysis
	Researcher field notes and memos	Daily during RESET PD	As needed

RESET PD Data Sources

Initial and Exit Interviews

During the summer RET program, I conducted two semi-structured interviews with each of the six teachers. Through the initial interview questions (see Appendix G), I explored teachers' identities as related to STEM teaching and as related to issues of social justice and cultural relevance (RQ 1a). The initial interviews were held during the first week of the summer SEER RET program and lasted approximately 20-30 minutes each. These interviews took place in an office in the solar laboratories building where the teachers engaged in Solar Cell 101. The exit interview questions (see Appendix H) also focused on teachers' role identities (RQ 1a). However, I also asked questions about the teachers' experiences in the program and the curricula materials they designed (RQ 1b). I conducted the exit interviews with each teacher during the final two days of the RET program in a room in the ERC building where the teachers worked while on the university campus. The exit interviews lasted between 25-40 minutes. With the teacher's permission, I audio recorded each interview. The interviews were initially transcribed through Rev.com's automatic transcription software. I then read through the transcripts with the audio and made corrections where necessary to ensure accuracy.

The purpose of RESET was to develop or support teachers' role identities and actions as culturally responsive STEM teachers. Thus, I needed to gain insight into teachers' identities, and the interviews provided a setting where I could do this. De Fina (2009) argued that rather than being "artificial social encounters," interviews were "interactional events" (p. 237). Narratives elicited by a researcher in an interview setting can have an authentic social purpose, but occur through different rules and relationships than other conversations. Interviews provided a rich source of narratives that supported my understanding of teachers' identity development. As Sfard and Prusak (2005) argued, "narratives that constitute one's identity, being an important factor in shaping this person's actions, will be useful in research even if they communicate one's experiences only as well as human words can tell" (p. 17).

Intersectionality Competence Measure

At the beginning and end of the summer program, teachers completed the Intersectionality Competence Measure (ICM) Subset A (Boveda, 2016; see Appendix I). The ICM Subset A, a set of 18 multiple-choice questions, was developed "to measure preservice teachers' intersectional competence, that is, their understanding of diversity and how students, families, and colleagues have multiple sociocultural markers that intersect in nuanced and unique ways" (Boveda, 2016, p. 17). These sociocultural markers, according to intersectionality theory (Crenshaw, 1989), include "categories such as gender, race, class, ability, and other aspects of identity" that "interrelate on multiple, and often simultaneous dimensions, contributing to systemic social inequality" (Boveda, 2016, p. 20). Thus, the ICM Subset A provided one way to gain insight into teachers' beliefs in relation to working with diverse populations of students. The ICM Subset A was developed and validated through an expert panel review, cognitive interviews, and a pilot test of the instrument. I created a Google Form survey with the 18 questions and sent the link to the teachers, so that they could complete and submit the measure digitally.

Reflections

After each key RESET event during the RET program, the teachers individually completed semi-structured written reflections in Google Documents shared with me. I read through the memos the same day they were completed to determine if we needed to spend any additional time addressing teachers' questions, concerns, or possible misconceptions. At the end of the program, I made a copy of each teacher's reflections to provide insight into their role identity development over the course of RESET (RQ 1a) and to provide insight into how to integrate a focus on CRT into teacher PD (RQ 2).

Group Discussions

In addition to the individual reflections, teachers also engaged in group discussions of key events. Each of these discussions was audio recorded in order to capture teachers' beliefs, feelings, concerns, questions, and insights on each experience, example, or workshop (RQ 1a), as well as how they feel they might be able to (or not) adapt and implement it into their work with students as culturally responsive science and engineering teachers (RQ 1b), and how these discussions evolve over the course of the program (RQ 2). The audio recording of each discussion, as well as the telling identity introductions, was transcribed verbatim.

Teacher-Designed Curriculum Plans & Materials

As part of the RET program each summer, teachers create a solar energy engineering curriculum to implement in their classrooms and to share with other teachers via the SEER website and a published handbook of activities. In the past iterations of the RET, teachers used a provided template for their lesson or unit plan development. They adapted the template as applicable or desired, but included the key elements in some form (e.g., connection to their state's adopted standards for STEM subject areas; detailed description of the curricula; assessment). During RESET, however, because we wanted teachers to create a curriculum that was responsive to their students and engage them in engineering design projects that were meaningful to the students, I told teachers they did not need to use the template and could present their instructional plans in whatever format would be most useful for them.

Teachers each had their own folder in a Shared Drive on Google Drive that I created to house all of the resources we used during the RET program generally and RESET program specifically. This drive was shared with the six teachers so they would have access to all of the resources throughout the program and beyond. Teachers used their individual folders within this shared drive to house the instructional plans and materials they created. I made a copy of these folders approximately once a week and saved them to the Google Drive folder where my dissertation data was stored, so I could get a sense of how the teachers' lesson development progressed as they participated in activities, discussions, and reflections across RESET.

School Year Data Sources

At the end of the summer program, during the exit interviews, I explained the school year follow-up portion of my dissertation study to each teacher and asked if they would be willing to continue their participation. All of the teachers participating in the RET agreed and completed the Consent Form (see Appendix J). Therefore, my data collection continued during the following school year for all six teachers, though only my interactions with the four focal teachers are included in the timeline (see Table 8).

Table 8

Timeline of Data Collection during the School Year

Date	Data Source	Teacher(s)	Location
September 30	Observation: Presentation Prep Meeting	Abby & Tom	Local Restaurant
September 30	Observation: Agri-PV Partnership Planning Meeting	Abby	Middle School
October 16	Artifacts: Presentation Slide Deck & Photos	Tom	University
October 21	Final Interview	Abby	Phone
November 1	Observation, Artifacts & Final Interview	Dean	Classroom
November 26	Final Interview	Tom	Local Restaurant
January 16	Observation: STEM Family Night	Julie	K-8 School
January 28	Observation: Students' Agri-PV Pitches	Abby	K-8 School
April 6	Final Interview	Julie	Phone
April 13	School Year Follow Up Survey	All Teachers	Online
All Year	Artifacts: Photos, Emails	All Teachers	Online

Teacher Observations

During the following school year, I planned to visit each teacher's school up to three times to observe how they implemented the solar energy engineering curriculum they created during the summer program and the culturally responsive pedagogical strategies and practices included in RESET (RQ 1b). During these observations, I used the attributes of CRT, as outlined by Gay (2018), to guide my field notes.

Due to a variety of constraints and then COVID-19, I was not able to conduct as many observations as planned. However, I was able to observe each of the four focal teachers implementing some aspect of their curricula or solar energy science and engineering activities at least once during the school year. With Tom, though, it was an indirect observation through a planning meeting, a presentation slide deck, and photos from the presentation. The education director and I observed Abby twice during the year in her role as a district facilitator of an Agri-PV project that took place with sixth graders at a school in the district. We also traveled to observe Dean, whose school is approximately five hours from the university, and to help him implement a *Solar Carnival* activity he had seen modeled during the RET program. I observed Julie as I assisted her with a STEM Family Night she arranged for her K-8 school community.

Final Interviews

I conducted a third interview with each of the teachers during the school year. Except with Dean, it was not feasible to interview the teachers the same day I observed them. So, I set up separate interview times with the teachers. I conducted each final interview (see Appendix K) either in person at a place of the teacher's choosing, or on the phone. I asked the teachers about how their experiences in RESET had influenced their identity and actions as a culturally responsive science and engineering teacher, student advocate, and change agent in increasing their students' access to and success in science and engineering (RQ 1a/b). These interviews lasted between 15-30 minutes and were audio recorded and transcribed using the same procedures as the initial and exit interviews.

School Year Follow-Up Survey

Due to the COVID-19 pandemic and the disruption of the school year and the teachers' lives in general, I chose not to try and conduct another interview with each teacher. Instead, I used Google Forms to create and distribute a follow-up survey to all of the teachers in mid-April (see Appendix L). All six teachers responded to the survey, answering questions about how RESET influenced their CRT practices and their ability and experiences implementing their designed curricula as well as other aspects of the RESET PD during the school year (RQ 1b).

Implementation Artifacts

Finally, throughout the school year, Dr. Jordan and I kept in touch with the teachers via email regarding their implementation of the curricula they created during the RET program and their related work, opportunities, and needs for support. These emails and any accompanying photos of activities the teachers were engaged in with their students were downloaded and saved to provide further information about the teachers' practices following their participation in RESET (RQ 1b). I also took photos of teacher and student artifacts (e.g., Agri-PV garden 3-D designs, science notebooks) whenever I was able to visit a teacher's school or classroom. Students' faces and other identifying information were not included in these photos.

Additional Data Sources

Researcher Notes and Memos

Throughout the RESET PD intervention and school year follow-up, I took field notes and wrote reflective memos. I created a Google Slides slide deck for each day of RESET with the day's agenda and slides to guide our work for the day (e.g., telling identity prompts, discussion focus). I took field notes in the note section of each slide as the day progressed or at the end of the day. I noted if we did not get to an activity planned for the day and recorded my observations about those activities we did do. At the end of the program, I saved each of these slide decks as a PDF file, with the notes visible, for analysis. Additionally, at least once a week, I engaged in reflective memoing in a Google Document about the design, adaptations, my concerns or questions, teachers' identities, and my own experiences focusing on the topics of CRT and issues of social justice with the teachers. I used these field notes to help answer both research questions, but especially RQ 2.

Conjecture Maps

As described in detail earlier in the chapter, I used conjecture maps (see Appendices A and D) throughout the study to help me plan the RESET PD and note adaptations that were made during the Year 3 iteration. I used these conjecture maps as part of analyzing what was learned about how to integrate a focus on integrating CRT into science and engineering PD (RQ 2).

Data Analysis Processes

Data analysis began during the study and continued throughout the writing process. The transcripts of teachers' interviews and group discussions and teachers' survey responses, written reflections, designed curricula materials, and implementation artifacts were uploaded into MAXQDA 2018 (VERBI Software), an application designed to facilitate the analytic coding process, on my password-protected personal laptop. I also uploaded my field notes and memos to MAXQDA 2018. Analysis of the conjecture maps took place in Microsoft Word on a copy of RESET Conjecture Map 2, subsequently renamed RESET Conjecture Map 3 (see Appendix M). In this section I overview my analysis process by research question.

Research Question 1 Analyses

Through the first research question, I sought to understand how integrating a focus on CRT into RESET influenced mid-career K-8 teachers. Specifically, how RESET influenced the teachers' (a) role identity development as culturally responsive science and engineering teachers and (b) curricula development, instructional practices, and actions as advocates and agents of students' equitable access to and participation in science and engineering. As I used similar analysis methods to address both parts of RQ 1, I discuss both here.

Cycles of Qualitative Data Coding

First Cycle Coding. My primary analytical strategy was to engage in cycles of qualitative data coding. According to Saldaña (2016), first cycle coding allows the researcher to summarize segments of data into codes. Codes are ''tags or labels for assigning units of meaning to the descriptive or inferential information compiled during a study'' (Miles & Huberman, 1994, p. 56). For the purposes of this study, the first cycle of coding included theory-driven, and data-driven, and structural codes. According to Decuir-Gunby and colleagues (2011) - who focused specifically on coding interview data related to teacher professional development - researchers determine deductive, theory-driven codes a priori from existing concepts or theories. Researchers develop inductive, data-driven codes through repeated examination of the raw data and structural codes from a study's goals or research questions.

Because of the varied and sometimes ambiguous ways the construct of identity has (or has not) been defined in the literature, Saldaña (2016) argued that "pre-established codes that relate to attributes…, culture, values, attitudes, and beliefs, for example, are most likely essential to studies about identity" (p. 71). Accordingly, I developed theory-driven codes based on Kaplan and Garner's (2017) conceptualization of the elements of DSMRI, (e.g., purposes and goals; perceived action possibilities). I also included theory-driven codes related to Gay's (2018) principles of CRT (e.g., socially and academically empowering; replacing deficit perspectives). I also developed structural codes to label parts of the data specifically related to teachers' role identities of interest (e.g., culturally responsive, mid-career, science and engineering teacher) and to different aspects of the RESET PD (e.g., experiences, examples, pedagogical workshops). I entered the theory-driven and structural codes, with definitions, into my codebook in MAXQDA in order to be able to apply them to sections of text as I read through the documents, also in MAXQDA.

I began my analysis by reading through the teachers' beginning interview transcripts and coding them with the theory-driven and structural codes I had developed. I sought to increase my understanding of teachers' self-reported role identities as mid-career STEM teachers and of their understanding of culturally responsive and social justice-oriented pedagogies before they engaged in the RESET PD. I then engaged in the same process for each teacher's exit interview at the end of the RESET PD. Throughout this process of coding the interview data, I also began creating and applying data-driven codes related to teachers' descriptions of the influences of various RESET events on their knowledge, understanding, and practices as a teacher (e.g., shift in understanding, questioning past instructional practice). For example, in her final interview, Julie noted,

> One thing that really shifted for me was, because I am a person who has said, "You know, we're colorblind in here. I don't care if you are green, purple, polka-dotted. It really doesn't matter to me." I didn't realize the way that could be interpreted, that then leads to their background and how that may not support their cultural beliefs.

I coded this text, which had also been coded as one of Julie's "ontological and epistemological beliefs" as part of her role identity, with the data-driven code "shift in understanding." Julie went on to explain an idea that had been shared by one of the other teachers in a discussion as a practice she would like to use the following year, which was coded with the structural code of "connection to a RESET discussion."

By coding the teachers' interview transcripts first, I was able to create a preliminary framework for understanding each teacher's role identities and trajectory of learning throughout the RESET PD. I next moved on to coding the transcripts of teachers' group discussions and reflections after each key RESET event in order to better understand how these events influenced the teachers' role identity development as culturally responsive science and engineering teachers, advocates, and change agents. I also sought to understand how these events impacted teachers' development of a solar energy engineering curriculum. Again, I coded using the theory-driven and structural codes, as well as the data-driven codes I had developed as I coded the interviews. During the process of coding the discussions, I created additional data-driven codes to capture the various aspects of students' intersectionalities that teachers discussed (e.g., gender, language, ability, race). I also began to code the discursive "moves" the teachers and I were making as part of the group discussions, such as making connections between aspects of the program or modeling being responsive to other participants.

In both the interview and discussion transcripts, I specifically coded the narratives teachers shared. As discussed previously, a widely accepted way of making sense of a persons' identity is through narrative discourse or "telling stories" (Connelly & Clandinin 1999; Cohen, 2010; Rodgers & Scott, 2008).

After engaging in first cycle coding for all of the data gathered during the RESET PD in the summer, I updated and finalized my codebook. I then re-read the data sources I had already coded to ensure I had identified all instances of each code. I then repeated the entire first cycle process for the data collected during the school year following the RESET PD. I coded the final interview transcripts, teachers' created curricula materials, and follow-up survey data using the codebook I had developed. I also used the implementation artifacts, my field notes and memos, and other observational data as needed to provide further detail or clarification as needed. I met with Dr. Jordan weekly throughout the analysis process to discuss and negotiate my coding decisions and findings.

Second Cycle Coding. Through second cycle coding, researchers "develop a sense of categorical, thematic, conceptual, and/or theoretical organization from [their] array of first cycle codes" (Saldaña, 2016, p. 233). In terms of addressing the first research question about how RESET influenced teachers' role identities, instructional materials and practices, and actions as an advocate and change agent, the second cycle coding was a multi-step process. I primarily used the process detailed by Garner and Kaplan (2019) to guide my analysis of each teacher's case and to better understand teachers' role identity systems in relation to the main role of interest: a culturally responsive science and engineering teacher. I focused first on the actions each teacher took in terms of their role identity as culturally responsive science and engineering teachers as they created instructional plans and materials during RESET and then enacted these plans the following school year. I then worked backwards through the data sources seeking to understand if each teachers' actions were influenced by elements of RESET and in what ways. In other words, I sought to understand what, if anything, was most influential for each of the four focal teachers, and if and how the four dimensions of their DSMRI shifted.

Using the Summary Tables feature in MAXQDA, I focused on the DSMRI codes for each of the four focal teachers' cases at three time points: the beginning and end of the summer program and during the following school year. I compiled summary and synthesis forms similar to those used by Garner and Kaplan (2019). I also noted in these summaries specific activities or events that teachers felt helped to shift or shape their role identity systems. I then composed "a single synthesis statement...to outline change and stability over time and to highlight portions of the analysis that mapped onto the research questions" (Garner & Kaplan, 2019, p. 13). I explained this process, shared the forms and statements, and discussed and revised them as needed with Dr. Jordan. Through this within-case analysis, I was able to describe and create a representation of each teachers' role identity trajectories across the program and into the school year.

As a final step in my second cycle coding, I did a cross-case analysis to look for patterns or themes in how the RESET PD influenced teachers' role identities and integration of the principles of CRT into their curricula and instructional practice the following school year. I used cross-case analysis to extend my understanding and ability to explain the influences of RESET, as well as to enhance the possible transferability of key aspects of RESET into other contexts (Miles et al., 2020).

Matrix Analysis and Analytic Memoing

In addition to cycles of qualitative coding, I also created matrices throughout the analytical process to help me address the first research question. According to Miles and colleagues (2020), matrix displays allow researchers to organize condensed data and codes "into an at-a-glance format for reflection, verification, conclusion drawing, and other analytic acts" (p. 83). For example, to analyze teachers' responses to the ICM Subset A at the beginning and end of the program, I created several different matrices to look at various aspects of teachers' responses. For example, I created a matrix for each teacher with their responses and explanations (if provided) for each question. This allowed me to look for changes from the beginning to end of the program and to note inferences about what could have influenced those changes from the program that I could check through other data sources (see Table 9 for an excerpt). I also developed a cross-case matrix to look for patterns in how teachers responded to various questions. Again, I created analytic memos with my thoughts, making sure to consider a variety of possible explanations, to guide further analysis and possible triangulation with other data sources.

Table 9

Excerpt from Matrix Analysis of Dean's ICM Responses

ICM Question	5/30/19 Responses	7/2/19 Responses	My Analysis Comments
For students who immigrate to the US from countries in which a language other than English is the dominant language, is it more important for students to be fully immersed in English in school than to spend time maintaining and developing their native language proficiency? Any comments related to the or your response?	Just as important as maintaining native language No comment provided	Slightly less important than maintaining native language I think you shouldn't lose your identity while trying to learn the English language.	Response changed Post: connection of language to identity; mentioned this in interviews and in the discussion after Dr. Adisa's talk
Should teachers ever group students of the same ability levels together? Any comments related to the or your response?	Sometimes group students by ability levels No comment provided	Rarely group students by ability levels: I think students learn more when they are challenged in mixed groups.	Response changed Post: Looks at mixed groups as challenging students which results in more learning Note: look for where we talked about this or if it was modeled in a program experience

Research Question 2 Analyses

The second research question of the study built on the first and focused on what was learned about how to integrate a focus on CRT as an inherent part of a science and engineering PD, such as RESET. As this study focused on one iteration of RESET, the purpose of this question was to explore both the affordances and constraints of the design in order to improve RESET for the next iteration. However, I also sought to contribute to the scholarship on how to support mid-career K-8 teachers in becoming more culturally responsive to their students' intersectionalities and to advocate and become change agents for students' increased participation and success in science and engineering courses and disciplines. Thus, the analysis processes to address this question focused on further cross-case analysis of the four teachers' experiences and trajectories in the RESET PD, as explored in RQ 1. Analysis also focused on the overall design and outcomes of the RESET PD intervention as represented in the conjecture maps I created.

RQ 1 and Cross-Case Analysis

Building on the cross-case analysis I conducted for RQ 1, across the four focal teachers' data, I looked for patterns and themes in the most influential experiences, examples, pedagogical workshops, or practices from RESET, focusing more on the design and implementation of these events and features than on the teachers. I looked at what teachers reported as being impactful in their exit and final interviews and compared that with my observations and teachers' curricula materials to get a better picture of what aspects of RESET transferred into their instructional practices and actions as educators.

I also looked for patterns and themes in if and how RESET influenced specific aspects of teachers' role identities as culturally responsive science and engineering teachers and teachers' actions related to specific CRT principles. This analysis allowed me to consider what aspects of RESET should be continued, adapted, added, or removed in order to help teachers develop and strengthen this role identity. As with the other analyses, I discussed and negotiated these findings with Dr. Jordan weekly.

Conjecture Map Analysis

As part of preparing for the next iteration of the RESET PD and exploring the processes that contributed to the outcomes, I also engaged in analyzing a copy of RESET

Conjecture Map 2 and recording findings related to each component of this map. I used an analysis process similar to the one used by Boelens et al. (2020). I determined whether each of the five enactment processes and three outcomes had been achieved, somewhat achieved, or not achieved. These determinations were based on my analyses of the other data sources. I updated the map to reflect the enactment processes and outcomes that had been achieved, somewhat achieved, and not achieved, through shading each enactment and outcome box differently to represent each (e.g., solid color, diagonal lines, no color).

Additionally, I used the findings from my analyses to determine whether the design and implementation of RESET had achieved the targeted conjectures. I then assessed whether the design and process conjectures, as represented by the numbers and letters between the three columns, had been supported (bolded), supported with limited data (normal text), or not supported (strikethrough). RESET Conjecture Map 3 (see Appendix M), with a key to the meaning of the different patterns, was the result of this analysis and provided a visual representation of the influences of the RESET PD.

Establishing Trustworthiness

DBR researchers aim to "provide a trustworthy account whereby a series of events—each of which is local and contingent—can be seen as part of an emergent and potentially reproducible pattern" (Cobb et al., 2003, p. 12). Lincoln and Guba (1985) argued that establishing trustworthiness in qualitative research involves establishing credibility, transferability, dependability, and confirmability. McKenney and Reeves (2019) explained how each of these criteria could be established in educational design studies through extended engagement with the intervention, thick descriptions of all aspects of the intervention and methods, consistent findings across iterations, and triangulation of data methods.

Credibility

In this study, I sought to establish credibility, or to determine if the study examined what it was designed to examine (Lincoln & Guba, 1985). To do this, I described my engagement in studying, designing, and facilitating previous iterations of the SEER RET program. I also detailed how I designed and implemented the RESET PD based on both my previous experiences and the scholarship related to the topics of interest.

Across the implementation of RESET, I consistently engaged with the teachers in the key events and in our critical discussions of these events. Teachers had multiple opportunities to discuss their identities and the influence of the RESET PD through these discussions and through the three interviews I conducted with each teacher. I also engaged in member checking (Miles et al., 2020) with the teachers (on the summaries I created of their role identities) and consistent check-ins with Dr. Jordan, the SEER program education director. I kept an audit trail (Miles et al., 2020) through my reflective memos written each day during RESET PD implementation, updated conjecture maps which captured design decisions noted in the daily memos, and my analytical memos.

Transferability

To show that the findings could be transferable into other contexts, including teachers' educational settings and future similar PD contexts, I provided detailed descriptions of the SEER program and RET sub-program. Further, I included a rich description of the theories that guided the development of the RESET PD intervention, its design features, how these features influenced participating teachers, and emerging theories from implementing the intervention (Barab & Squire, 2004).

In addition to describing these aspects of the study and intervention, I included justification for the initial design and decisions related to RESET, the iterations and changes made during the study, and the criteria used to interpret and include data in the final report (Cobb et al., 2003; Hoadley, 2004; McKenney & Reeves, 2019). Finally, I sought to situate the findings and insights from this DBR study into the broader theoretical contexts of culturally responsive science and engineering teaching and teacher PD in order to contribute to or advance the field of study (Barab & Squire, 2004).

Dependability

In this study, I began to establish dependability, or to show that the findings were consistent. As this was the first iteration of the RESET PD as part of the RET program, and as the COVID-19 pandemic disrupted the regular implementation of the SEER program in 2020, I have not yet had a chance to implement the next iteration. However, I used within and cross-case analyses and several data sources to explore the experiences of the four teachers to look for consistencies in how RESET influenced their identities and instructional practices. Additionally, I detailed how the previous RET iterations informed the design and implementation of the RESET intervention.

Confirmability

According to McKenney and Reeves (2019), "Confirmability relates to objectivity, and deals with the extent to which the findings of a study are shaped by the respondents and not researcher bias, motivation, or self-interest" (p. 260). One of the primary ways I established confirmability in this study was through triangulating data collection methods. For example, in exploring what aspects of the RESET PD influenced teachers' role identities as culturally responsive science and engineering teachers, I looked at their comments in discussions, reflections, and interviews. I also, though, looked at the curricula materials they created and my field notes from observations during the school year.

Another way I established confirmability was through reflexive memoing focused on looking for alternative interpretations of the data through asking myself, "What else could this be?" I also used reflexive memoing to capture my own biases and emotions when working through the data. Especially given my desire to focus on fostering teachers' identities as science and engineering instructors committed to culturally relevant teaching and addressing issues of social justice and equity with their students, I did not want to unintentionally undermine my purpose by reinforcing hierarchical, inequitable power structures during or after RESET or in my analyses. Thus, I kept two lists of questions for researchers to consider on my computer and in my planning binder to refer to often throughout the design, implementation, and analysis of RESET: 13 Points of Consideration (Boveda & Bhattacharya, 2019) and Bang and Vossoughi (2016)'s questions that focus on issues of critical historicity, relationality, and power in DBR.

The 13 Points of Consideration "guide a shift from the desire to reinscribe imperial and colonial forms of knowledge-making to knowledge-making driven by considerate and love-based ethics" (Boveda & Bhattacharya, 2019, p. 18). For example, one of the points of consideration highlights the need for researchers to identify what a "dignified, respectful, and ethical relationship with participants [would] look like within the context of a study" (Boveda & Bhattacharya, 2019, p. 21). Similarly, Bang and Vossoughi (2016) emphasized the need for DBR researchers to ask, "What forms of life are our partnerships and designs reinforcing, powering, validating, and transforming? How do particular places, histories, and moments in time shape what is right or wrong and for whom?"

I sought to assess these questions in my study this through sharing my own sociocultural and professional identities with teachers, in order to highlight both the similarities (e.g., background as a K-8 mid-career teacher) and differences (e.g., current status as a doctoral student and researcher, racial or cultural differences). Throughout the study, I intentionally positioned myself as a facilitator of teachers' experiences, examples, workshops, and related discussions in RESET rather than as an expert. Teachers were able to connect with experts in a variety of areas and with a variety of perspectives through their program participation and were able to critically evaluate their experiences in terms of their own identities and what would be most responsive to their students. I also sought to establish authentic relationships with the teachers that carried on beyond the program and to provide resources and support to the teachers as needed during RESET and the following school year.

CHAPTER 4

RQ 1 FINDINGS AND DISCUSSION

In this chapter, I report and discuss key findings related to the first research question of the study: How does integrating a focus on CRT into a designed PD intervention (i.e., RESET) - through critical discussions of program experiences, examples, and pedagogical strategies - influence mid-career K-8 teachers' (a) role identity development as culturally responsive science and engineering teachers, (b) science and engineering curriculum development and instructional practice and actions as advocates and agents of students' equitable access to and participation in science and engineering? I address findings related to this question for each of the four focal teachers' individually and then across the four cases.

I begin with Dean's case, as he was the only elementary school teacher participating in the RESET PD, and then present the cases for the two middle school teachers, Tom and Julie. Because of Abby's district role working with teachers in grades K-8, I focus on her case last. For each teacher, I first present a summary of the findings from my analysis and then provide a more detailed description with supporting data. The supporting data often includes lengthy quotations from the teachers in an effort to ensure that teachers' voices are represented along with my analysis and interpretations of their words. This practice is in keeping with the research on teacher identity, and the importance of teachers' own narratives of their identities (Connelly & Clandinin, 1999; Cohen, 2010; Rodgers & Scott, 2008). It is also an important part of recognizing that my interpretations, which - though I sought to reduce bias as much as possible - cannot be completely separated from my knowledge and intersectionalities and are not the only possible interpretations (Bang & Vossoughi, 2016). Therefore, I sought to include the teachers' own words as much as possible.

Case 1: Dean - Tension Between Goals and Contextual Constraints

In terms of his role identity as a culturally responsive science and engineering teacher, Dean's context was unique. Unlike the other teachers, who identified as White, but taught at schools where the majority of their students came from different cultural, ethnic, and racial backgrounds, Dean, who identified as Navajo, taught at a school in Navajo Nation where all of his students were also Navajo. Dean was already highly validating of his students' cultures, especially emphasizing the importance of learning and maintaining their Diné language. However, Dean came to the summer program experiencing tensions in his role identities, and specifically between his goal to integrate more student-centered inquiry practices into his science and engineering instruction and his perceived action possibilities within his school context.

During RESET, Dean found that the pedagogical workshop on using students' funds of knowledge in engineering instruction resonated with him and expanded his perceived action possibilities for the following school year. In terms of navigating contextual constraints such as the focus on literacy and mathematics in elementary school and his administrators' desire to see more traditional instructional strategies, Dean was able to gain ideas from other participants and the lessons modeled by Jade, as well as integrate resources from the program into his reading instruction.

Achieving Purposes and Goals

One of Dean's goals as a teacher in Navajo Nation was to validate his students' culture, a key aspect of CRT. Dean especially tried to include aspects of students' Navajo culture and language in his teaching. For example, in his initial interview, Dean expressed his passion for helping his students learn their native Navajo (or Diné) language:

> I am always lecturing them about learning the Navajo language.... because they are Navajo. And they need English too, but when they go somewhere else, people will still see them as Navajo, so they should know the language because it is part of them. We really work on reading and writing in English because they will need that in anything they do, but I always lecture them about learning Navajo.

While Dean acknowledged the need for his students to know English, he also made the point that “people will still see them as Navajo.” He had found that his students did not want to learn the Navajo language, “because of media and the things they are interested in. They don’t think [the language] is useful because no one else speaks it. But it is still part of their culture and part of being Navajo.” Dean expressed that, though the students continually received messages through the media and others that their language and culture were not useful, people outside of their community would still “see” the students as being Navajo, regardless of whether or not they learn the language. Thus, Dean wanted their Navajo language and culture to be a priority for his students and something they embraced as a strength, rather than something that they saw as unimportant.

Dean also noted in his initial interview that one of his professional goals was to build on his students' interests and "what they bring to the table." He believed that his role as a teacher was "about the students. It's what the student has learned, what the student brings, what their interests are, and what talents they have." In other words, Dean valued the CRT attribute of teaching to and through students’ strengths (Gay, 2018).

Despite having this goal, however, Dean reported feeling he had not done this as well as he would have liked.

In his introduction to the other teachers at the beginning of the program, Dean noted that he perceived his own strengths as “tinkering with things and figuring things out” as well as “trying to model curiosity and staying positive...keeping with it.” Thus, Dean believed that science and engineering learning should be centered in active, hands-on group work and projects related to students’ interests. Dean explained that this type of learning kept his students “really interested” and helped them to “learn how to solve problems and use their knowledge in real ways.” For example, in the previous school year, Dean had engaged his students in building ramps and using these ramps and “calculators to calculate speed, force, and friction,” integrating standards from both science and math through an engineering project. Dean reported his belief that “getting to build things is the best way for [students] to learn and get excited about [engineering]."

Navigating Contextual Constraints

However, Dean reported tensions within the context of his school which shaped his perceived action possibilities related to implementing the type of instruction he felt best engaged his students and supported students’ strengths. While Dean wanted to structure his science time so that his students would be working on their own science and engineering projects, he worried that “it might seem like it’s unorganized, and I think convincing the principal that the students are actually doing projects would be a challenge for me.” Dean further explained that “I think to the principal, it will look like it’s chaos and everybody’s not doing what they’re supposed to be doing. I think, even though there’s learning occurring it wouldn’t seem so to the principal.”

Dean also reported struggling to balance the many external expectations and ongoing changes with his desire to focus on students' interests and talents. For example, as is common in elementary schools, reading and mathematics content was more focal than science and engineering content. Dean had made efforts to integrate science topics through having his students read informational texts and articles from their adopted reading program, but he found it more difficult to add more inquiry-based, hands-on activities. Despite having taught for nearly 20 years, in his initial interview Dean stated that he was looking into further training in a healthcare profession, specifically as a phlebotomist, because he wanted a backup in case he did not "make it" as a teacher. The tensions in his role identity as a mid-career teacher made him doubt his ability to remain in the profession (Santoro, 2011).

Influence of RESET on Dean's Role Identity

Given Dean's guiding goal of integrating and using students' strengths in a project-based science and engineering learning environment, the concept that most resonated with Dean during RESET was funds of knowledge (Moll et al., 1992). For our pedagogical workshop and discussion about funds of knowledge during RESET, the teachers read a short article by Sias et al. (2016), which focused on integrating students' knowledge and experiences from home and from their culture into their engineering projects. Some of the teachers had the opportunity to have their students complete the Funds of Knowledge Survey (see Appendix E) at the end of the previous school year and they brought their students' responses. I also brought examples of student responses that I had collected. During our discussion, we talked about funds of knowledge and what strengths and assets the students had listed on their surveys that the teachers could then use in their engineering instruction.

It seemed that learning about the concept of funds of knowledge gave Dean a concrete way of thinking about integrating his students strengths, or talents, into the classroom. In the teachers' conversation with Jade after their second observation of her with her students, Dean said, "I'm trying to wrap my mind around the funds of knowledge. Where does funds of knowledge apply in your system, in your program?" Jade highlighted two main points. First, she explained her focus on empowering students:

> How many of our kids think that they're rich in knowledge? …. First of all, [students] have to realize what assets they have. Asset building needs to be an actual activity in your setting. If you want to build leaders, they have to understand that they have assets and that they don't always need to look like somebody in a textbook…."

Jade highlighted the importance of engaging students in things that are meaningful to them and of actively highlighting and building their assets.

Jade then went on to talk about her second point, which was helping students learn to navigate the current system, so that they would have access to more opportunities and could work to change these inequitable practices. For example, in Jade's district, students cannot take advanced science unless they pass the standardized test at a certain level, and that if they do not get into advanced science, they will not have the same opportunities moving forward. So, teachers need to help their students learn that they are "worthy" of these opportunities, but also help them understand that they often have to "jump through hoops" in order to be in a position to change inequitable practices.

Then, in order to tie her response to directly to Dean's situation as a lower grade elementary school teacher, Jade related,

> I went and visited a school in Las Vegas. First graders were designing their own engineering design experiments, collecting data, writing down data, taking pictures with their iPads, and then doing group presentations about their claims, evidence, and reasoning. Literally using those words. First grade. I'm like, "Are you kidding me right now?" This is the stuff that we expect our fifth graders to do. And it's not that they can't do it. It's that we, for some reason, accidentally or not accidentally, lower the bar. The question is, why? Why don't we raise the bar and then scaffold? Why don't we stand there by their side and go, "I got you. Fall. I got you. And try again, and try again, and try again."

Jade consistently reinforced the idea of having high expectations for students, but then supporting students and giving them the room to fail and continue to try. Students even in the youngest grades could flourish in these conditions. The YS MS students echoed these ideas when the teachers interviewed them, explaining that the chance to retake tests (on their own time), get additional help afterschool, and access the resources and notes Jade uploaded to their Google Classroom whenever they needed them helped them to be more success and learn more in Jade's class than in other classes where they did not have this support or these opportunities.

Dean's initial ideas for the instructional materials he wanted to create included using a problem-based or inquiry approach to learning the content and integrating students' strengths. In our first brainstorm of curricula ideas, Dean brought up two science standards for second grade that focused on energy. The first focused on the transfer of energy within a closed system. Dean referred back to an activity modeled on the first day of the SEER summer program by a past RET, where students "act out" the movement of energy within a system to show "how they understood energy." Abby supported this idea, explaining that "I think your grade two is very, very curious about: How energy does work, and how energy does move?"

In terms of the other standard about organisms requiring energy and often depending on or competing with other organisms for this energy, Fernando shared an idea with Dean about having students make connections between plants and solar cells. For example, Fernando suggested having students "test ideas" and answer questions about what makes their plants "grow better":

> "If I tilt the angle of the pot? Did that affect it? Or even if I had a color filter, does that affect it?" So, you do the same thing with a solar cell… And then kind of do the analogy of the solar cell and the plant simultaneously, and hopefully they will see, "Oh, there's some similar needs that would be happening for both of these to work."

Abby built on Fernando's idea and suggested that Dean's students could "measure the energy of a solar cell" and "watch the plant" in the shade for two weeks and compare that to when the solar cell and plant were in the sun.

Bianca then shared an idea about using solar-powered water fountains that she had seen in a past training. Julie built on that idea, and suggested,

> there's all kinds of little solar panels or solar toys that you [i.e., Dean] could use. Just put them out in front of [the students] and ask, "Why is this moving? Does it move when I put it in the shade? Does it move when you flip it upside down?"

At this point, all of the teachers continued to build on their own and others' ideas. Fernando suggested, "Also, you could ask the temperature. Because maybe the plant doesn't work really well in the cold temperature but the solar cell does. So, you can kind of contrast that." Bianca mentioned an extension to the water fountain activity and noted that "we need to give [students] flashlights or other types of light and see if [the fountain] works." In the meantime, Tom had found the solar fountains online and shared the information with the group. While Dean noted that these ideas were "cool," they got lost as we moved on through the program because the participants had just shared the ideas in our rapid-fire discussion style, which did not always accommodate the participants who were quieter or who wanted time to work through and think about ideas instead of jumping from idea to idea.

In terms of the influence of RESET on Dean's beliefs about students' intersectionalities, Dean seemed to become more confident in his responses and comments at the end of the program. He had only provided a few comments to clarify his responses to the ICM (see Appendix I) at the beginning of the program, but included comments for most of his responses to the ICM at the end of the program. For example, when responding to the item about whether privilege and access are associated with "the combination of masculinity, White skin, and wealth," Dean did not provide a response in his first ICM, but wrote the comment: "I'm not familiar with this question because the majority of our population in Window Rock is Navajo." However, on the same item at the end of RESET, Dean responded that it was "slightly associated with that combination" and commented that "when I was in the military, I sensed that that combination had better opportunities to get easily trained and get advancement."

In Dean's initial response to Item 15 on the ICM about the importance of students' maintaining languages other than English was that being fully immersed in English in school was "just as important" as students maintaining the native language. However, at the end of the program, Dean responded to the same item by indicating that being immersed in English was "slightly less important" than maintaining their native language. Dean explained that "I think you shouldn't lose your identity while trying to learn the English language." While this had seemed to be Dean's stance all along, as evidenced by his comments in his initial interview, he only included it in the final ICM. Similarly, when responding to Item 13 regarding the importance of being responsive to students cultural and linguistic needs, Dean selected "just as important as addressing students' reading or mathematical abilities" at both time points. However, at the end of the program, Dean made the comment that "the cultural and linguistic can be used as a building block to begin with."

Another notable change in Dean's ICM responses came in his responses regarding students' ability levels. At the beginning of the program, Dean responded to Item 16 that "teachers should sometimes group students by ability levels." However, at the end of the program, Dean responded that "teachers should rarely group students by ability levels" and commented that "I think students learn more when they are challenged in mixed groups." In terms of his responses to Item 5 regarding whether non-white students are improperly placed in special education classes, because of his specific context, Dean commented at the beginning of the program that "I've heard stories about non-White students ending up in Sped classes." At the end of the program, Dean provides a more specific version of the same comment, “I’ve heard that a number of struggling non-White students are usually labeled as special ed even though they’re not in a non-White setting.”

In his final interview at the end of the RET summer program, Dean reiterated his goal to incorporate students’ strengths and funds of knowledge the following school year:

> I would like to become more aware of the funds of knowledge that the students bring to school and use that as a teaching tool also. And hopefully [the students] would use that to plan their future in education and careers.

Here Dean referred to the activity Jade did with her students about finding their purpose, but he also talked about how he planned to integrate students strengths and interests into his science and engineering instruction. Dean explained that he wanted to use

> problem based learning and let students choose the way they want to present things, the way they want to solve things. Through that, I think the teacher would be able to see where this student is coming from. [Because] through problem based learning. I think I've learned some things about my students, about what talents they have and what things they do most of the time.

Dean saw implementing problem-based learning as a way to learn about and engage his students.

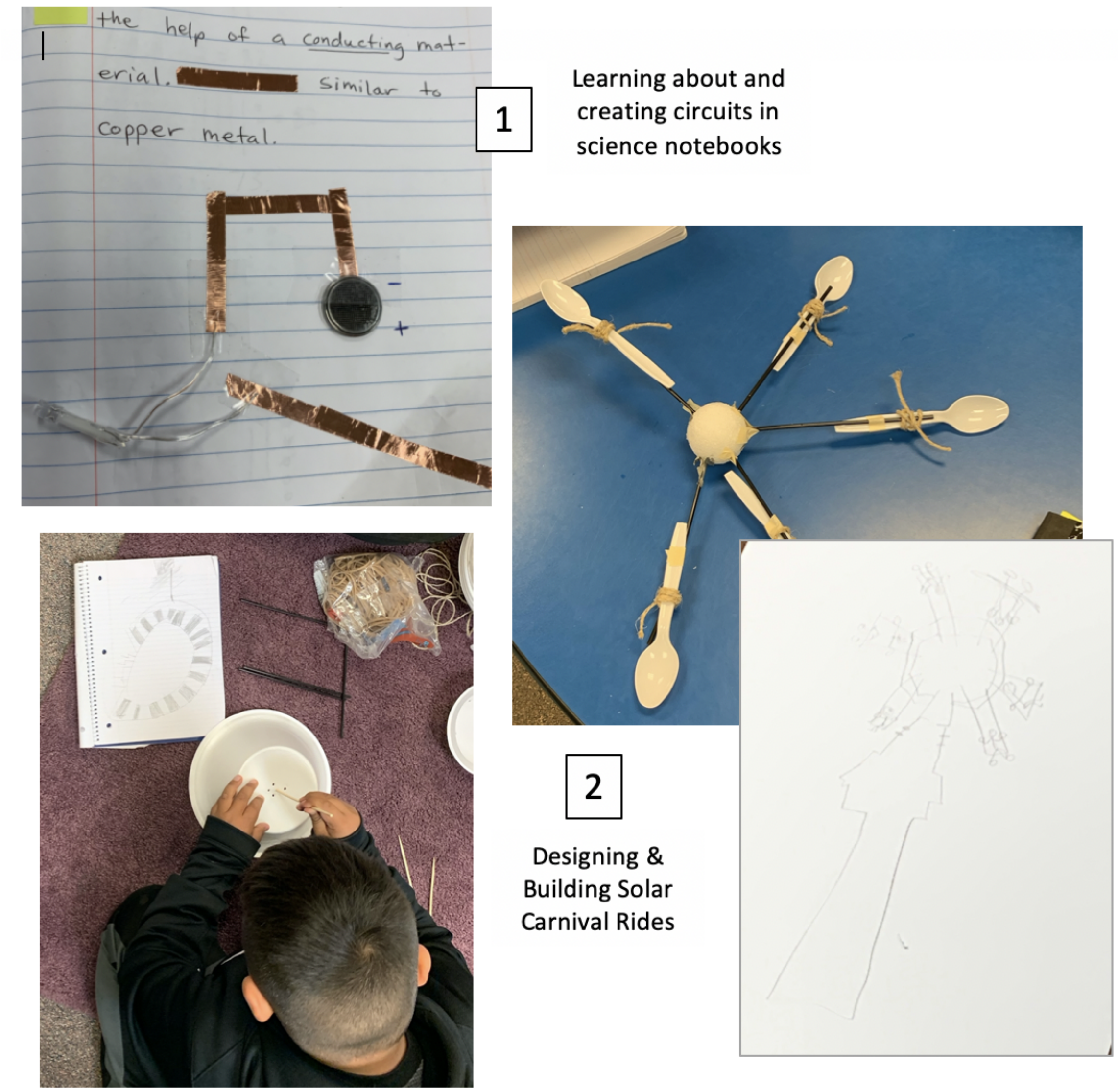
School Year Actions

Incorporating Activities and Actions Modeled in RESET

Instead of integrating his own ideas and instructional materials the following school year, Dean generally recreated the activities he had engaged in himself during the program (e.g., Solar Carnival) or that he had observed Jade implement with her students (e.g., creating circuits). He was able to successfully adapt these activities, which were generally implemented in middle school, to work for his second grade students. In November of the following school year, Dr. Jordan and I traveled to Dean's school to observe him implementing the Solar Carnival lesson he had participated in during RESET with his students (see Figure 4).

Figure 4

Photos from Dean's School Year Implementation



Though second graders were the youngest group we had ever seen participate in this activity, the students eagerly engaged with creating a design for a solar-powered carnival ride on paper, and then creating a prototype of their design to test. Because Dean had already introduced his students to how to run a small fan with a motor and solar cell, the students jumped right into the activity. Most of the groups of students quickly created something, then went to test their design with the light source. They did not seem to be highly worried about failure, just returning to their workspaces to adjust their designs. During our final interview following this observation, Dean noted that after his participation in the summer program he had tried to "take a chance at doing hands-on activities" more often in his classroom, and that the "kids really enjoy it."

In terms of his general classroom practice, while I was interviewing Dean in his classroom after school, one of his students came back into the classroom and handed Dean his homework then left again. Dean explained that this student liked to have his weekends free to play, so he would do his homework right after school on Fridays and return it. This type of flexibility and adapting to students' preferences was something he was trying to incorporate more often since his interactions with Jade and her students.

Ongoing Contextual Constraints

For Dean, the main challenges the following school year remained the same and included the external time and content constraints that often come with being an elementary school generalist. In his follow-up survey, he reported, "My challenge was creating opportunities to let students apply their funds of knowledge daily due to the expectations of completing reading, math, specials, and intervention blocks." Dean felt he could not spend as much time letting students "apply their funds of knowledge" to projects and learning because of the highly structured expectations of the school, district, and state. Each day, his students spent time outside of his classroom in “specials” (i.e., physical education, art) and in intervention blocks (i.e., blocks of time during the day where students are assigned to work with teachers or instructional aides based on their academic achievement in reading or math skills). During the time Dean had with his students in his classroom, he was expected to focus on reading and math.

Dean navigated these challenges using some of the strategies we had discussed during RESET, such as integrating science and engineering content with literacy lessons. He explained that, “My 2nd Graders did reading and writing activities related to solar energy at least twice a week. Students kept journals to draw and write what's been learned.” He also ordered informational texts on a variety of science and engineering topics to use with students. For example, that week they were reading about jellyfish and how the jellyfish were different colors. “So, I was thinking we could use LED lights to design jellyfish and put them on the wall so they can somehow relate [what we’re learning in science] to the book that we’re reading.” In this case, Dean could have students recreate the circuits they had designed in their notebooks to light up the LED lights in a project that would integrate content from several different areas.

Dean explained that “my students learned about the different ways solar energy can be used. They combined their background knowledge of how things work with the new knowledge to build creative models.” Dean hoped to give his students additional opportunities to use their funds of knowledge through the projects the students created in the spring for their school Navajo fair. For this event, the students would design hogans, a traditional type of Navajo home, and then engineer ways to integrate solar energy into their design. Dean explained,

> The students would build a home that's related to the different tribes. I'll probably ask the question: what would the tribal members' home look like and how would you use solar to improve that? So, basically, we'll start from there and they will draw a picture and start building [models], considering the land where they are at for the things that they use.

In the past, students had just created a model of what tribal members' homes would look like in order to help them learn more about their ancestors. However, that year, Dean wanted to integrate an engineering component into the fair, where students could consider what resources would be on different tribal lands and use those to adapt the design of the home to include solar. Unfortunately, due to COVID-19, the fair was not held during and the project did not take place. During the following school year, even though Dean's school remains online, Dean has sent home materials to allow his students to engage in activities from RESET.

Case 2: Tom - Focus on "Moving Up"

In terms of fostering the focal teachers' role identities and actions as culturally responsive science and engineering educators and advocates of students' equitable access to and participation in science and engineering, RESET had the least influence on Tom. Tom's actions during RESET and the following school year were largely shaped by aspects of his broader role identities as a mid-career teacher and white male. As a mid-career teacher, Tom's driving professional goal, as expressed in his initial and final interviews, as well as during his introduction to the other teachers, was to move to a leadership position within his district. As a white male, Tom explained in his initial interview that he held "definite opinions" and beliefs about issues of social justice and equity that often did not align well with the principles of CRT and students' equitable access to science and engineering discussed in RESET. However, Tom's perceived action possibilities for becoming a more responsive science and engineering teacher did expand during RESET, especially through his interactions with Jade Whipple and the YS MS students. Ultimately, though, Tom's participation in the RESET PD had little lasting influence on his actions the following school year.

Focusing on "Fairness"

Several of Tom's ontological and epistemological beliefs did not align with the principles of CRT and students' equitable access to STEM courses and careers discussed in RESET. This disconnect was apparent in several of Tom's responses on the ICM (Boveda, 2016) administered at the beginning of the program. For example, Tom responded that "non-White students are never improperly placed" in special education classes and that only "a slight number of parents and families possess knowledge and expertise that can contribute to students' success at school" (Items 5 and 9). In regards to the latter response, Tom noted, "This depends on the diversity of the school and students." Both responses demonstrate a deficit orientation not only towards students, but also towards students' families, especially within diverse communities and schools.

Tom also responded that learning English was "slightly more important" for students who spoke another language, because "their native language is important, but learning English will be much more important in the long run if they are going to stay in the US." This is evidence that Tom does not see the relevance of sustaining students as multilinguals (something that is included as part of validating students through CRT and other resource pedagogies; e.g., Paris, 2012), as "English will be much more important" to their success. Tom also implied that only students coming from outside of the US would speak languages other than English, demonstrating a common misconception that CRT challenges.

Despite these deficit-oriented responses, Tom also provided responses to a few items on the ICM that seemed to align well with the attributes of CRT. For example, Tom noted that "a good teacher would always adjust" their instruction to accommodate the needs of all students and selected the response item that "being responsive to cultural and linguistic needs of students was just as important as addressing reading or mathematical abilities" (Items 8 and 13). This response highlighted the CRT practices of using a wide variety of instructional strategies and approaches and recognizing the importance of diversity in learning (Gay, 2018). Overall, through the responses Tom selected on the ICM, he seemed supportive of the idea that teachers needed to facilitate success for all students generally (e.g., "good" teachers always adjust instruction for students), but less supportive of the CRT-targeted validation and support of cultural and linguistic differences (e.g., actively encouraging the sustaining of a language other than English).

During his initial interview, when asked which issues of social justice and equity were most relevant to his students, Tom focused on his perceptions of the sociocultural context and students in his school and district:

> I'm in a title one district, so the kids are very impoverished, to say the least. And I think there's a lot of issues. [The students] just need to know what's available to them, what they can do. I think the biggest issue we're dealing with is showing the

> kids what's available to them. You know, they don't realize they can go to college. So, a lot of stuff we push on our campus is [about] college.… So, we're trying to get kids to realize they can go farther than their parents ever have. And so, we're trying to push it that way.

In this statement, Tom described his students from a deficit perspective, as "impoverished" and needing to "realize they can go farther than their parents ever have" rather than from the asset-based focus of CRT, where students' backgrounds and family experiences are valued and built upon (e.g., Moll et al., 1992; Sias et al., 2016).

Tom also noted his belief that "the biggest issue" was helping the students to know what was available to them. Tom perceived the students as lacking awareness of future options rather than considering the broader social and educational inequities implicated. Tom believed that the teachers and school, by providing this awareness, would allow the students to "go farther," at least as defined by the educational system. Tom did not address any issues of equity in terms of what the school or teachers could do to make their practices and policies more responsive to and equitable for the students. Instead, Tom only shared something the school had implemented to encourage the students to be more responsive to the goals the school felt were important. The school goals for students also framed students' success as in competition with rather than in cooperation with (a central aspect of CRT) their parents (Gay, 2018).

In his initial interview, Tom went on to explain his beliefs about other social justice and equity issues broadly. Rather than reflect on how these issues impacted his students, he focused on the impact on schools generally, and by extension, how they impacted him professionally. For example, Tom explained he had "very definite opinions" about the "whole Mexico border issue." In connecting his beliefs to education, he stated that "if the borders are open, your schools keep getting filled with students that need help. And that's not necessarily fair either." Tom ascribed to the deficit belief that students coming from other countries, and specifically Mexico (as is common with his students), "need help." As Milner (2011) explained, this kind of "deficit thinking can cause teachers to look upon culturally diverse students as liabilities rather than assets" (p. 62), in other words, as a problem to fix. In CRT, on the other hand, teachers work to build on the strengths students have and how they can contribute to the classroom community as they simultaneously work to support the needs of the students (Gay, 2018).

Instead of a focus on equity, Tom often discussed issues in terms of what was "fair." In addition to the example just mentioned, Tom spoke extensively about his own experiences, especially as related to race, and his perception of these experiences:

> I've gone through times in my life where I felt like I was the minority. I applied to work for [a large city's] police department back years and years ago. [Through a testing and interview process,] I finished in the top 20 [applicants], and they were hiring 50 people. And I didn't get hired, because they didn't have their quota of Blacks in the department. Because the city was more Black than it was White. So, they had certain quotas. So, they moved all these people to the front. And I didn't get a job that year, even though I was in the top of that. I was discriminated against because of my color. So, I do know what it's like sometimes… And I don't think that's fair either direction. You can't say, "Well, you have to have…" I understand why they want to, but it's also not fair, you know?

Tom believed that because he scored well on the testing and interview aspects of the job he should have been hired. Tom did not consider that these aspects of the hiring process were often developed or conducted by - and therefore often biased toward - those who looked like him (e.g., Bendick & Nunes, 2012; Roberson et al., 2017). Furthermore, he did not consider other criteria, such as sharing a racial, ethnic, and/or cultural heritage with many of the residents of the city to be important beyond filling a "quota."

Tom then explained his general belief that this idea of a "quota" has repeatedly worked against him when he feels he is more qualified for a job based on specific criteria that are important to him:

> I felt there's a lot of times in my life when I was discriminated against because I am the White male. Because, "we don't have our share of Black, Hispanic, female…" whatever it is they're going to throw in and say you have to have this. That now became a whole nother set of discrimination. And so, I think we've got to work through all those things. I wish people could get hired for the job that they can do. You know? And if they can't do that job, which there's a lot of people in every field, ... bring the person that can do that job. And if that person changes and wants to be something different, let them do that. But I don't know, I guess we have quit putting people in groups based on who they are instead of what they are.

Throughout the program, Tom consistently expressed this belief that certain groups of people are often hired because of their sociocultural identities (e.g. "what they are") to fill quotas, even if those people are not qualified to do the job. He did not consider that the issue might be his (and others') perceptions of what makes someone qualified for a job.

Despite these types of responses and narratives, Tom reported his perception of himself as someone who tried “to be very open minded on things and I am on most things.” However, Tom then explained that “I have a couple of things I'm very adamant about, but that's always going to be me…. I can have my opinions as long as they're my opinions. Nothing should ever change that.” He again connected back to his strong belief of focusing on what people do over “who they are:”

> But it's what we do and how we do things…. I think that my entire life has been focused on helping people: in the Marine Corps, being a police officer, being a teacher. It's always been about other people for me. So, it doesn't matter what my opinions are, I'm obviously doing something about trying to fix everything else. So, I have a few things that way that's not a big deal because it still doesn't matter to who I am.

Tom listed his past and current roles as evidence of his focus on “helping people.” This focus aligns well with the CRT practice of centering cooperation and connectedness, as long as the focus is on all members of the classroom community helping each other, and not just the teacher “trying to fix everything.”

However, Tom’s assertion that “nothing should ever change” his beliefs or opinions about issues of culture, race, or equity was problematic. While an important part of CRT is recognizing a diversity of opinions, Utt and Tochluk (2020) cautioned that teachers’ opinions and beliefs could result in “subconscious enactments of racial privilege [that] negatively impact communities, injure students of Color, and display poor modeling for White students” (p. 133). In other words, Tom’s deficit beliefs were not harmless in the enactment of his role identity as a science and engineering teacher.

(Lack of) Influence of RESET

Tom’s beliefs about “fairness” factored into our discussion after a key RESET event. As I facilitated the discussion with the teachers about Dr. Adisa’s presentation, I again mentioned the underrepresentation of most groups of students (e.g., females, students of color, differently abled students) in STEM fields. I highlighted our focus in the RET on finding ways to increase all students’ equitable access to and participation in science and engineering classes, degree programs, and careers. As the discussion continued, Tom expressed his concerns about what I had shared:

> It goes back to [Wendy] saying we need to give [students] the opportunity to do that. We want to push that opportunity [to participate and succeed in science and engineering], and show them they have the opportunity. But what happens ... I don't mean to say this as a fact, but more of a question. What if the reason why some of our numbers [related to who enters STEM fields] are where they are is because that's what people want to do? It's like us saying, "Well, 20% of the population is, let's say Hispanic. Therefore 20% of the jobs have to go to that." And you have seven kids there, and they go, "None of us want to do that, though. So why do we have to?" Are we pushing people into something they don't want to do, or are we simply providing the opportunity for them to be able to? That part I totally understand. But I also don't want to get us to the point where we start worrying so much about the numbers, that we're saying, "It has to happen this way. Therefore, you may not want to do this, but we don't have enough, so you have to go do this.” Because now that's not fair, either.

In response to Tom, I clarified that our purpose was not to “push people into what they should want” but to evaluate the extent to which students who did want to continue in science and engineering classes and eventually careers had access to those pathways through their educational experiences, and the possibility of success.

Tom acknowledged this point and connected it to Dr. Adisa’s talk. However, Tom also restated his concerns:

> That's the biggest thing I took out of [Dr. Adisa’s] talk - Are we presenting kids with the facts to say, "This is available to you." Because she said the kids didn't realize that they could be an astronaut. They thought they had to be the cleaning lady. Are we providing them with the opportunity to say, "This is something you can do. Any one of you, sitting here, can do this job, if you want to"? Don't believe you can't. I think that's instilling in kids the desire to learn, the desire to grow, and the desire to be themselves, and realize that the only door that's closed is the one you don't open. I think we need to present that to kids, but again, it comes back to the fact that we can't say that you, and you, and you have to do this, because we need this, and you and you have to do this, because we need that. It's giving them opportunities, but letting them make those choices.

Tom continued to be concerned about the idea of “quotas” that he had discussed in his initial interview, and that in education teachers were “pushing” students into something they may not want to do.

Through this open-ended critical discussion following Dr. Adisa’s presentation, several of the other teachers engaged in addressing Tom’s concerns. Fernando, as a self-identified Mexican American, noted his personal experiences that, “as a person who has participated in diversity programs and groups, I've never felt I was forced to be a part of that program… [or seen] the program force [students] into something. I've never felt that, at all." Both Abby and Julie argued that students cannot know or choose whether or not to continue in science and engineering if they are not meaningfully engaged, with support, in these subjects and understand the future possibilities of continuing to engage. Abby provided an example of the types of responsive conversations she felt teachers should have with their students:

> I want to be really realistic with you. Here's where the job market is. Here's where the high-paying jobs are. And there's going to be a lot of opportunities. You can make the decision, but I want it to be an informed decision. I want you to understand the potential that you have, and what your life could look like. Maybe you want to travel. Because if you want to travel, with your language skills, and with your dedication, and the commitment that I see in you, there's this global market for you.

Tom acknowledged Abby's point, but continued to hold onto his belief that we "push" students into careers they do not want based on their sociocultural identities. Julie then countered, re-emphasizing the idea that exposing students to many possible futures was not forcing students onto a path. It was providing students options, knowing that these students may later decide to pursue science or engineering, even if they were not currently interested.

Though Tom's beliefs did not seem to shift throughout this conversation, having the discussion after Dr. Adisa's talk did provide the chance for Tom to share his perception of "forcing" students into science and engineering careers. This discussion also provided an opportunity for Tom to hear the perspectives of the other teachers, who argued against his perspective. This discussion also gave me, as the facilitator and researcher, an opportunity to gain insight into how Tom was thinking about a focal topic of RESET and adapt the PD accordingly.

Tom chose not to complete the ICM at the end of the program, despite multiple general and specific reminders. My perception of this choice, based on my accumulated experiences with and knowledge of Tom, was that it was an indicator of Tom maintaining his beliefs about issues of social justice and equity, his right to his opinions, and the importance of action over beliefs.

In his exit interview at the end of the program, Tom discussed several things that are part of the school system that he perceives as injustices. For instance, he stated that

> Sometimes there's just kids [whose] goal is to make people miserable, and I don't think they belong in a regular classroom. They need to be somewhere else. And sometimes that's special [education]. And we actually in our district have a program where we send kids to an alternate school ... How do we make our classrooms more effective? Part of it is some kids got to come out of that classroom.

Though Tom acknowledged areas where he could improve in his practice as a culturally responsive teacher, he persisted in his deficit thinking about certain students. Tom did not specifically mention any aspect of students' intersectionalities or identities in this statement, research has shown that students of color are overrepresented in both special education and school disciplinary action (Souto-Manning, 2019).

Tom also mentioned one other area he considered to be inequitable in the school system - the overemphasis on college preparation:

> I also think that we don't do justice by giving kids enough opportunity. Sometimes we need to show kids alternates… Everything we do is college ready. It's not career ready. Career ready would give kids options and we don't. If a kid has to have four years of language arts and four years of math and three years of science in three years to graduate, there is a lot of careers that don't need all of that…. They don't need Algebra 2. Some of these kids would be lucky to pass Algebra 1, but they need fundamental math but we don't give them those things…. If we're truly going to be college and career ready, we need to have a split track and by high school, some of these kids need to be on a track for careers and for college and we need to change that. And then we'll have much more successful kids. When we used to have, you know, woodshop and automotive and home-ec and all these other things, we had kids that were career ready or life ready. We're not worried about that anymore. We're going to pump them full of 22 credits required to graduate and make them do it. And that's not fair to the kids. And so that's where social injustice is right now.

Again, Tom does not make this point in relation to any particular aspect of students' intersectionalities. However, the focus on split tracks and positioning certain students as not being able to succeed in college, does not reflect CRT's focus on ensuring academic and social success for all students and teachers showing students that they believe in them.

Seeking Leadership and Increased Impact

Related to Tom's beliefs about the importance of roles and "helping" others, Tom's actions during and after the RESET PD were also shaped by his professional purposes and goals. In his initial interview, Tom explained that while he enjoyed teaching, his professional goal moving forward was to "move out of the classroom and do something different. I'm ready for coaching or academic coaching or administration and to move up. So, I've been putting a lot of applications out... and working towards that."

Tom often talked about his desired leadership roles as a way to "move up" or to take his career "to another level." During his initial interview, Tom explained this idea of advancement or hierarchy in terms of the number of people he could impact:

> When I was a police officer, I only impacted four or five, 10 people a day. That's it. You know, you don't make a difference in the world. And so…it still is very limited, what you can do. When I became a teacher, it was the same thing. I impact a hundred kids a year directly. I had 115 students [last school year], so that's it. I impacted 115 students. As a coach or an administrator, I can impact a thousand kids a year. You know, I can do things that are going to help. So that's my goal.

Tom also commented that he might consider running for a political office, such as a state senator, in the next few years, so that he could "impact a lot more people." Tom summarized his purpose for seeking an administrative position as, "I want to have more of an impact on things. I can have a big impact on the classroom but have a bigger impact outside the classroom." Moving up in the hierarchy to Tom meant being able to influence more people, something that he had stated as a professional goal. However, he did not ever provide specifics of this vision for his influence, beyond numbers (e.g., "10 people a day"). Because Tom does not focus on how he would "influence" other people in administrative roles, it seemed as if Tom defined influence in terms of the number of people he interacted with or that he supervised during a period of time rather than focusing on the quality of those interactions or the positive consequences for others.

Influence of RESET on Tom's Role Identity

As part of the RET program requirement to create curricula materials, Tom chose to design a curriculum for the following school year that related to his interests in solar energy and leadership roles. On the first day of RESET, teachers shared their preliminary ideas for instructional materials or projects they would like to design for the following school year. Tom explained the solar energy engineering project he wanted to develop for the school year implementation in partnership with Abby because of her role in the district supporting teachers:

> We're looking at a feasibility study to increase and put more solar on the campuses [in our district] in some form. Check it out. Find out what it would take, what it's going to cost, what kind of options there are, the different ways in which we could do that, looking at financing, looking at what's available for stuff to do and figure out how we can make this happen.

Initially, Tom was not considering this project in terms of involving his students the following school year. Rather, he explained that he could choose an energy issue and "go around at PDs in different schools and present the ideas and the thoughts." He would tell the teachers "the plan and get them to fill out information [about their practices] if need be." This goal is in keeping with his mid-career goal of working in a leadership role.

Abby then mentioned that he should "get the students to pitch [the idea]" and be part of the process. Tom agreed that would "be even better."

Ultimately, Tom envisioned this energy audit as something he would pilot by doing it with his own district. Then, he could offer the "blueprint" he developed to other schools or districts to do similar audits. Thus, the project could be a potential entryway into a leadership role or a wider impact. Throughout RESET, Tom developed a PowerPoint presentation for his "Carbon Footprint Reduction Project." He envisioned having his students update this presentation as they studied solar energy during the school year. Then, either Tom or the students would use it to present the project to possible partners and to district administration.

In terms of RESET's influence on Tom's role identity related to culturally responsive science and engineering, Tom discussed the influence of his interactions with Jade and the YS MS students. During his exit interview, Tom commented:

> Our interactions with Jade and her [students] have really been eye opening in a lot of respects of how I can do things differently in my classroom. I think the interactions with her kids have been huge for where I'm headed with what I'm doing. So, it's always nice to hear other teacher's perspectives and to hear it from the kid's mouth really helps too…. And there's some things I can just stop and think about and maybe make some changes to what I'm doing.

Tom recognized, through interacting with Jade and the YS MS students, new action possibilities for his own practice. He acknowledged the importance of being able to hear from other teachers and students, something he was rarely able to do in another PD.

These interactions also led Tom to reflect on his past actions and self-perceptions. Tom explained that while watching Jade and her students, he thought, "Oh yeah, I'm not doing any of this stuff. There's so many things I could be doing." He was especially interested in what the YS MS students had expressed during the RESET teachers' discussion with them and "the way they respect [Jade's] classroom because of the value she puts into it. The kids respected those things… [Jade] definitely has a different way of doing things than most people do it, but she's getting good results."

Because of the way her students talked about Jade, Tom acknowledged that, "I could make a few changes and try a few different things, and see how they work out that way too." Tom explained that he was sometimes sarcastic with his students when he had to tell them something multiple times, but he recognized that he needed

> to think from [students'] shoes and stop sometimes. And the way [Jade's] kids talk about her, I would love to have my students talk to somebody else about me that way. That would be cool. So, I thought, you know, if I want that to happen, I probably have to do some things differently.

Though this comment still primarily focused on the benefit of these practices for himself (e.g., "students talk to somebody else about me"), Tom was at least acknowledging the possible need for change.

Tom's experiences interacting with Jade and the YS MS students during the teachers' observations in their classroom also influenced what he perceived he could do with his students the following year:

> I liked the fact that we were able to talk and work through everything and solve problems. Sometimes I would just sit back and not really put a whole lot out, just

> listen to what they were saying rather than try and lead. And that was really hard for me sometimes because I like to take charge and do those things. So, I was very deliberate about not being the leader in everything I did and letting them take the lead as often as possible…. And so, for me that was a different role to get to do. It taught me a lot about what I could do in the classroom too, because I could do the same thing there…. We don't teach all the time, we lecture… and I think I could teach [students] better by not lecturing them so much… give them way more freedom on how they do things. I've tried to do that over the years, then I get lazy and just go back to my regular habits, which is not always good.

By getting the chance to work cooperatively with the YS MS students when the teachers participated in their activities, Tom noticed how empowering this type of collaboration, which is an important part of CRT (Aronson & Laughter, 2016), was for the students.

Tom went on to discuss his plans for the following year in terms of how he could be more responsive to his students, based on what he had learned in RESET:

> And I think next year as part of what I'd like to work into it is give them more options… and give them more freedom to choose and do things. Because at the end it really didn't matter. I realized at the end of the year it really didn't matter what all I taught them. The question is, what do they walk away with and what did they learn? And so, if they learn a few things on their own, that might be more important than learning hardly anything with me pushing it all into them. So maybe if they take more of an interest in themselves and are more participatory, they might walk away with more than what I do.

Tom recognized that when students were more engaged in and responsible for their own learning, they “might walk away with more” than if he continued teaching the same way he had been teaching.

By the end of RESET, Tom seemed to have gained some understanding through these interactions of how he could be more responsive to his students the following year. He explained,

> … So, it's more about, I think learning to read our kids better and that's, that's a hard thing to do in a class of 25 or 30 kids, to be able to read all of them. But we need to learn some of the things…. And so [my instruction is] going to be more focused on watching [students], finding their strengths, and see what I can build on there… So that's going to be really about changing some things this year and looking at the way, trying to see it more through their eyes and see what they do. I'm just going to try some new things this year. I'm going to open it up and give it some more opportunity and you know, okay, you can't do this, and then what can you do? How can you show me this? How are you going to represent this for me? … So, it'll be interesting.

In this comment, Tom referred to the CRT practice of teaching to and through students’ strengths (e.g., “finding their strengths and see what I can build on there”). Tom also mentioned allowing students to show their understanding in a variety of ways, according to what they can do.

School Year Actions

In his follow-up survey completed near the end of the school year, Tom noted how he had implemented aspects of the RET program into his classroom instruction throughout the year:

> I focused a large part of my year around the work and curriculum that we learned and created. It was fun integrating so much of it into my existing plans and using it as a key focus for everything that I did. We did a section on solar cell fabrication and I showed videos and used materials that I created over the summer.

Tom did not provide many specific details about his classroom implementation, in either the follow-up survey or exit interview, despite my pressing him to do so. Moreover, he did not revisit his plan for being more responsive to students through giving them more choice and listening to them. When specifically asked in the follow-up survey about which culturally responsive practices he incorporated into his classroom, Tom wrote, "I work in a Title 1 district, and I am always working to incorporate practices that include all of my students. This year we worked with students on opportunities related to utilizing our natural resources and reducing waste." Thus, as evidenced in this response, Tom felt he was "always working to incorporate practices" that would include all of his students, though he provided no details about these inclusive practices. Tom also seemed to imply that working in a Title I district, either forced or resulted in him being a culturally responsive teacher.

In his final interview, Tom highlighted how he shared the experiences he had during the summer program and attending a solar energy conference during the school year with his students. He concluded:

> I think the fact I can be more passionate about [the solar energy content] makes a difference. When [the students] feel that you are passionate, they get more engaged in it. And it definitely is more credible, because you know what you are talking about. Like when I was gone to the conference for two days, I came back [to school] and could talk about the things that happened and the things I saw. I share all this stuff with them, they know that I know what I am talking about and it means a lot to me.

Tom reported being able to share his passion for solar energy and sustainability, as well as being able to talk about the experiences he was having related to these topics. However, there was little evidence that Tom engaged his students in similar engineering projects they were passionate about or positioned them as contributors rather than just as learners.

Carbon Footprint Reduction Project

In terms of the Carbon Footprint Reduction project that he had designed, Tom was able to work with Abby and Dr. Jordan to get his ideas ready to present to engineering students at a local university to see if any of them would like to partner with him in implementing the project. Though I was not able to observe in Tom's classroom, I did attend the planning meeting where he prepared to give his presentation and received photographs from his presentation (see Figure 5). Tom's project was chosen by a group of students, and he worked with them throughout the year.

Figure 5

Photo from Tom's Carbon Footprint Reduction Project Presentation

During a later meeting Dr. Jordan and I had with Tom to discuss the project implementation, Dr. Jordan asked Tom if he was "thinking of this project as something you are going to involve your students in." Tom replied:

> I would like to, but again, how does that work in? I was thinking once [the engineering students and I] get it done, having [my] students come in and present it to the [district school] board, saying, "These are the things we can do. These are the things we have. This is what we could get out of it." I don't want this to be, yeah, it will provide nice shade for the teachers' parking. That's not really about what it is. It's that we can have the energy in these low-income schools. Because there is none. You drive around the neighborhoods that I teach in, there are no solar panels on the roofs there. These kids don't know what solar panels are, other

> than what I am telling them. Here we can have it there, go out and talk about it. Electric vehicles are coming big time, there is so much to talk about with those. With these solar pavilions – if people could drive in and charge their cars while they are at school. Because when does solar energy come, when the sun is shining. Teachers could have their cars charging and it doesn't cost the school a dime, because of solar panels.

Tom mentioned that having some sort of solar installation on the school campuses would allow teachers to introduce solar to students, because he believed that his students "don't know what solar panels are, other than what I am telling them." Tom had received a kit with small solar panels and other materials he could use to engage his students in exploring solar energy and solar panels, but he did not use them. Tom then went on to talk about the benefits for teachers of being able to charge electric vehicles, again returning the focus to his own goals and purposes. Despite his plans for becoming more responsive to his students and teaching to and through their strengths, Tom only followed through on enacting aspects of his designed curriculum that aligned with forwarding his personal and mid-career professional goals and interests.

Administrative Role

Tom's goal to be an administrator and his beliefs about fairness seemed to shape his actions and responses during the school year interview. Tom explained that "I love all the new things I am doing [related to solar energy science and engineering], but I'd really like to be out of the classroom." During the school year interview with Tom at the end of November, Tom explained: "I'm not totally happy because I'm not doing what I want to do yet." Tom explained that he had applied for several administrative positions, but had not been hired for any of them.

In terms of Tom's educator role identity (Garner & Kaplan, 2019), his purpose and goal was to become an administrator. His self-perception was that he was qualified for an administrative position though his experience, knowledge of the school and district, and master's degree in administration. Yet, he was not being hired when positions came open. When his principal explained that she did not feel that he was prepared for an administrative position at the school, he drew from his belief that the problem or issues were centered in the principal's insecurity or fear of his "power," rather than in something further he needed to do or change. Thus, he was re-evaluating his future action possibilities, in terms of his probability of accomplishing his goal within the current school or district against the financial costs of changing districts. Tom expressed the emotions that had defined this process as being "not happy" in his current position as a classroom teacher, and "irritated" with the principal's decisions.

In the end, Tom's goal to be an administrator and his focus on his belief in fairness intersected in experiences the school year following his RESET participation and left Tom questioning his future action possibilities. There continued to be tension between his actual role as a science and engineering teacher and his desired role in a leadership position. As shown in DSMRI, these tensions and the resulting emotions can impact teachers' actions, even as related to other role identities (Garner & Kaplan, 2019).

Case 3: Julie - Recognizing Students' Intersectionalities

Like Tom, Julie came to the program with clear professional goals. Unlike Tom, her goals were classroom and student centered. Julie wanted to "bring more meaningful

STEM activities into the classroom to solve real world problems” and to increase STEM opportunities at her school “in hopes to inspire the love of science and create aspiring career pathways.” Julie also came with strong beliefs about the importance of community and supporting all students. She believed in establishing a classroom culture where students were valued, but did not feel comfortable bringing in a focus on students’ insectionalities. Julie often told her students that their differences “didn’t matter” within the classroom, feeling that this type of general inclusiveness was best for all of her students.

Through RESET, Julie came to understand the importance of validating all students’ cultures and strengths (Gay, 2018). She also discovered new action possibilities for empowering students through engineering in ways that impacted others and built a broader community. During the following school year, Julie was able to integrate some of these actions with her students, but found herself having to navigate challenges in her context that restricted her action possibilities. Ultimately, by the end of the school year, Julie had accepted a position teaching eighth-grade science at a school in another district, where she felt she would be able to better enact her role identity as a culturally responsive science and engineering teacher.

Validating Students’ Cultures

Many of Julie’s beliefs and actions as a teacher focused on relationships, community, and supporting students, some of the foundational aspects of CRT (Gay, 2018). When Julie introduced herself to the other teachers at the beginning of the RET program, she noted that her strengths were “relational capacity” and “building a classroom community." In her initial interview, Julie further evidenced her focus on getting to know her students. She reported,

> I feel like I get really good at knowing [students'] needs and being able to modify [instruction] for them and knowing when their need is real, or if they are just saying, "I can't." Then we do a lot of growth mindset and failures. I think that helps build the community.

Julie often shared ideas related to the CRT attribute of educating the whole child in terms of being aware of and supporting students' social and emotional states in addition to their academic needs. For example, Julie noted that getting to know her students allowed her to better understand which of a range of possible social-emotional and academic causes a student might have for saying "I can't" when asked to do something. She also tried to support her students through equipping them with tools (e.g., a growth mindset) that were commonly touted as being helpful for increasing student success.

In her initial interview, when asked about which issues of social justice and equity were most relevant to her students, she first discussed issues of access experienced by differently abled students. For example, Julie expressed concern about finding ways to support her "students who have an IEP, who are struggling just to sort of get through the concept and what that means." Julie also highlighted "the other end of that spectrum:"

> those gifted and high achieving kids get left out of the equation a lot and we don't think about how to help them and how frustrating that must be for them to just be waiting for that next piece. So, I don't think they always get equal access, unless they're in a specific program, like a gifted program.

In addition to her focus on issues of equity related to students' abilities, Julie also noted another group of students who she believed did not "always get equal access:"

> For our Title I kiddos, how do we help build background knowledge and real life experiences for them? I've been in schools where we don't get to do a lot of field trips, so they don't have a lot of that background knowledge [like] what an environment at a zoo might look like, just those real life experiences that help them be able to connect real life to the science that you're talking about.

For this last group, Julie seemed to refer to students from lower income economic backgrounds, as that is the primary qualification for schools to be designated as a Title I school and receive additional funding.

In this case, Julie describes these students from a deficit perspective, stating that these students do not have the "background knowledge" and "real life experiences" that will help them connect to the science concepts she is teaching. Interestingly, in expressing concerns about each group of students' "equal access" to learning, Julie referred to a deficit in the educational system that is at least in part responsible for these issues. For example, Julie cited a lack of funding for field trips for her students' lack of science background knowledge. While Julie did acknowledge an issue beyond the students, she still focused her comments on what she perceived the students had not received from home, rather than on the science and engineering-related assets (Samuelson & Litzler, 2016) and funds of knowledge (McLaughlin & Calabrese Barton, 2013; Wilson-Lopez et al., 2016) they did have that she could build on through her science and engineering instruction.

In the ICM item related to whether students' parents and families have knowledge and expertise that can contribute to students' success at school (Boveda, 2016; Item 9), Julie responded that "a fair number" did. Julie also commented that "this is highly dependent upon the area the school services. I chose a middle of the road answer because I have worked at schools at both ends of this spectrum." Julie does not clarify how the "area the school services" is related to parents and families' knowledge and expertise. However, Julie again appeared to hold a deficit view of families from lower income economic backgrounds.

Julie's hesitancy to respond to or comment on questions related to issues of social justice and equity was evident through some of her responses to the ICM. For example, when responding to Item 4 regarding privilege related to masculinity, white skin, and wealth, Julie responded that privilege is "fairly associated with that combination." She then commented, "Unfortunately I do think this happens more often than I want to commit to." Further, Julie responded to Item 17 that it was "not at all a part of teacher responsibilities to help students question gender role stereotypes" evident in instructional materials or in the educational setting. Julie commented:

> This scares me! Although [my students and I] do have some conversation about this, I am always scared to death that I will offend some students and their families. I only address this issue as a type of respect-all-humans conversation.

This comment provided additional insight into Julie's lack of comfort with explicitly addressing issues of students' intersectionality in her classroom. She was "scared to death" of offending others, so she preferred to take more of a general view that we should "respect all humans." Like Tom, Julie chose not to complete the ICM at the end of the program. Perhaps this decision was related to her discomfort with addressing topics of social justice and equity generally, which is especially common among White teachers (Milner, 2011; Utt & Tochluk, 2020).

Influence of RESET Julie's Role Identity

One of the most influential RESET events for Julie, in terms of her culturally responsive science and engineering teacher identity was Dr. Adisa's talk and the teacher discussion after this talk. In her exit interview at the end of the program, Julie described the shift in her beliefs that resulted from her experience during these events:

> I've always, at least I hope, been aware or tried to be pretty cognizant [of being responsive to my students]. I think the one thing that really shifted for me was, because I am a person who has said, "We're colorblind in [our classroom]. I don't care if you are green, purple, polka-dotted. It really doesn't matter to me." I didn't realize the way that could be interpreted and how that may not support their cultural beliefs and things.

In this excerpt, Julie expressed her belief that by stating she did not "see" color, she was providing an emotionally safe environment for her students. However, as is central to CRT (Gay, 2013), teachers need to validate and empower students through their cultures and races, not undermine them through blanket acceptance statements.

Julie then explained:

> As I kind of thought about, well, what do I really mean when I say that? It's not really that that's not important to me. It's that [students are] all valued to me, no matter what. So, I'm looking forward to how I can adjust that statement to make it mean what I want it to mean without having unintended negatives behind it.

Dr. Adisa's discussion helped Julie to see that what she had considered to be responsive to all of her students was actually invalidating aspects of their sociocultural identities and not allowing Julie to build her instruction on students' cultures and strengths (Paris, 2012).

During the discussion with the teachers following Dr. Adisa's presentation, Julie was also able to share her strengths and her focus on community and relationships, allowing her to connect her learning in RESET back to her purposes and goals as a teacher. The teachers were discussing how different types of student responses in their classes were perceived as being "disrespectful" to the teacher. However, through the presentation and this group discussion following, they were looking at the importance of seeking to understand the student and the possible cultural or individual influences on the students' responses instead.

Julie gave the example of teachers getting upset with students "because you think they just came at you in a derogatory tone" rather than trying to understand the context of the response. She explained that

> it goes back to building that culture of respect within your classroom from the get-go… Even though I'm the adult, that doesn't mean that I have to be that person, that authoritative teacher... it's that moment where we say, "You're right, I made a mistake, thank you for helping me to see." … But that moment in the room, where you and a kid have that conversation, and everyone sees that, and they look at you as the adult who just backed down and said, "Oh, you're right." That moment is powerful, when they realize I'm not the end-all, be-all. It doesn't have to be that

> way, then that relational capacity starts building, where you can have all of those conversations we're looking for.

Here, as in general, while Julie did not participate in the RESET discussions as much as some of the other participants, whenever the discussion focused on issues of relationships with students or establishing community, Julie openly shared her experiences and expertise with the other teachers. By connecting her learning during RESET to her own purposes and beliefs as a teacher, she was able to strengthen her own role identity and contribute to the other teachers' learning.

In her exit interview at the end of the program, Julie explained that she wanted to incorporate activities that built on and validated students' cultures and to "talk very specifically" with students about what she was doing: "We're being aware that you have this culture or [other intersectionalities], and it's okay that we talk about it." She acknowledged her discomfort with these types of conversations, noting that "too often, we're like, 'I don't know if I should say…'." However, she continued, "I think when you're aware and… if we can get to a place where we're comfortable [talking about it], and then you start [having these conversations] in some lower grade, and then it filters up, eventually it spreads." Through her increased awareness of the issues, especially from Dr. Adisa's talk, and her engagement in conversations about these issues in discussions with the other RET teachers and Jade, Julie was at least able to perceive the possibility of having these types of conversations with her students and even encouraging other teachers to have these conversations.

Empowering Students Through Engineering

In addition to her focus on classroom culture, community, and relationships, Julie was also passionate about science. In her initial interview, she noted her perceptions of herself as “a total nerd when it comes to science.” However, she also explained that “I don't have a broad background in it. I actually didn't realize how much I enjoyed science until I started teaching it and started realizing that it's kind of a passion of mine.” She wished someone would have helped her discover this passion “earlier on,” so that is something she tried to do for her students. She explained that she made sure to show her enthusiasm for what their class was studying and for the everyday science students encountered in their lives. Julie explained that she would ask students “‘Did you know….?’ And then I kind of nerd out on it, and I think that they appreciate that.”

Following the RET program, Julie would be teaching science and engineering at the middle school level - seventh and eighth grade - for the first time. Julie was excited for the updated science and engineering curriculum standards adopted by the state where she taught, that would be implemented the following school year. Coming into RESET, she was fairly confident in her instructional strategies for science, but less so for engineering. Julie explained that in her science classes she commonly asked students,

> Can you tell me why? And I encouraged them to explain it for themselves and did exploratory lessons. I try really hard not to front load [students] with a bunch of vocabulary or background knowledge. I just asked them what they think. And then later we start answering those questions and guiding them into their own discovery, rather than “Here’s a worksheet, and answer these vocabulary words.

In addition to helping students to master the academic content, Julie found that this approach gave students a "level of comfort and motivation" where they wanted to "try something else. So, then they're not as nervous to expand out and try new things…new ideas and concepts."

While some of the science content she would be teaching the following year was new to her, Julie was finding ways to increase her knowledge, such as learning more about solar energy through the RET program. However, Julie was not as confident about integrating engineering into her science instruction. She explained, "again, [engineering] is something I don't really have a vast background knowledge in" and that engineering, until recently when they were added to the standards, "have not been my main focus." So, she continued, "the engineering part is definitely the one that I need to work through the most." Julie was not sure where she could "get engineering in" to "make sure [students] get that component across all science [topics]." Julie gave the example, "when I'm talking about tectonic plates, how do I get an engineering component in there? … Bringing in that extra piece is not always the easiest."

Influence of RESET on Julie's Integration of Engineering

As Julie sought additional knowledge about how to integrate engineering into her science content and how to make her science and engineering instruction more meaningful to students, participating in the RET program generally and RESET specifically helped expand her perceived action possibilities in these areas. During our first brainstorming session discussing the types of instructional materials teachers wanted to create, Julie shared that she did not know what she wanted to do. "I have a lot of ideas, and then I keep changing my mind." Julie noted one idea she had been thinking about:

"[Our school has] an after school STEM club, with a monthly focus. So, then I thought one of our STEM focuses could be on engineering, the engineering process of creating a solar cell." Building on this idea, Julie later partnered with Abby to create an Agri-PV engineering unit, where students would design and create school gardens (i.e., "agri," or agriculture) with a solar installation (i.e., "PV," or photovoltaics) to help provide shade, power irrigation systems, and so on.

In her exit interview, Julie explained how she came to choose to focus on this project:

> I really had a hard time nailing down what I wanted to do for my project. My battle really came down to, I could do just a good lesson and align it to my curriculum, but... I feel like I've been given this time and support to create something that could be even more beneficial. I could sit down and write a lesson plan or a unit… almost at any time. So, I really kind of wanted to go bigger since I had the support and especially because Abby was already doing [Agri-PV]. To have a teammate that, I was like, "You know what? I really want to do this. Can we collaborate on it?" That was kind of my ultimate deciding factor.

Julie felt that RESET provided her the time and support to "go bigger" in terms of what she wanted to implement the following school year. Additionally, having the opportunity to collaborate on a project, even though Julie and Abby would implement it in different ways in their respective schools and districts, allowed Julie to embrace something she would not have considered otherwise.

Julie explained that, through the RET program, she had learned about "different uses for solar" energy, beyond putting solar panels on rooftops, such as an Agri-PV installation at her school. Julie explained how she saw this project as developing something that would not only engage students, but also families:

> I really envision being able to do this, and then our families are really involved. When [the families] start seeing things [related to the Agri-PV installation] going up, and when they start asking their kids about it, and how do I include the campus so that we start just getting families to start talking about it? Like it's a common thing at their dinner table: "So how's your solar garden?" You know? Just to start getting the awareness.

Julie sought to do something that was not just specifically about her students, but that would connect the school with the broader community. This connection to community is central to CRT and to fostering students' rightful presence in STEM (Calabrese Barton & Tan, 2019).

Julie also explained the influence of interacting with Jade Whipple and the YS MS and YS HS students during the program:

> [Jade's] incredible. It's really nice to watch that other lessons be modeled by great teachers. And then also, not just to go through it as a simulation as a teacher, but to see how the kids respond too. It was really helpful. All of those experiences we did with [Jade] really just stuck out.

Teachers do not often get opportunities to watch other teachers teach, and Julie appreciated not only getting to see how Jade implemented the lessons, but how the students responded.

In her exit interview at the end of the summer program, Julie shared perceived action possibilities she had developed about how to weave everything she had learned during RESET together in a way that engages students in “real life” work that supported their school community and validated their various intersectionalities:

> Something I got really strong out of [RESET], especially seeing the [YS MS], was when we empower our kids and give them a voice, there is nothing more powerful. I can say it all day long until I am blue in the face. But when a kid comes out with it, whether they're trying to pitch a project or whether they're trying to help other kids or whether they're just buddying up to do a project together, that's really when you get the power behind it. So, I'm trying to think how I can utilize and empower my students to find their voice and to start wanting to do projects or be involved in challenges … with engineering and science practices, but that could also be done to help with social and cultural awareness.

In the excerpt above, Julie expresses her desire to not only engage her students in meaningful science and engineering projects, but also to be empowered, an attribute of CRT (Gay, 2018), to “help with social and cultural awareness” in her classroom and school.

Julie provided a possible way to do this, through a maker space that already existed at her school, but was underutilized:

> That's where I was thinking about the maker space. I can have my STEM club run little things for classes to come in [and do]. Then if I can prepare them and they can show a teacher how to take a kid through, that might help teachers start [knowing] what to do, opens the door for them maybe a little bit. Because … when you get kids doing [the teaching and training], I think that's where people start paying more attention.

Julie was excited to explore further possibilities to empower her students to engage in meaningful engineering work. Through her participation in RESET, she had perceived new action possibilities for engaging her students the following school year in ways that were responsive and empowering.

School Year Actions

Facilitating Classroom Discussions

In her follow-up survey completed near the end of the school year following her RET participation, Julie explained that she had "discussed a lot more scientists and tried very hard to break the idea that all scientists are old white men with crazy hair :)" with her science classes. She found that students "laughed at first, until they began realizing their own misconceptions. I noticed a lot more of them redefining what it means to have an interest in science." Julie also explained that "There isn't a lot [of curriculum] out there that is already created that addresses the situation. My teaching has been forced to be more cognizant and purposeful in this area." She found that it is most difficult to do so when she gets focused on "rolling through standards" rather than addressing misconceptions about who can do science and engineering. This emphasized common contextual constraints experienced by teachers: limited time and pressure to be moving quickly through standards to prepare students for high-stakes testing (Sandholtz et al., 2019).

Julie found a way to integrate this type of discussion with her students through the second RESET observation activity with Jade and the YS MS students. In this activity, Jade had drawn a diagram of four intersecting circles: 1) what you love; 2) what you are good at; 3) what you can be paid for; and 4) what is needed. Jade wrote the following words in the intersections between circles: 1/2) passion; 2/3) profession; 3/4) vocation; and 4/1) mission. In the very middle of all of the circles, Jade drew a star to represent “purpose.” Jade then engaged the students in an activity related to the diagram and finding their own purposes.

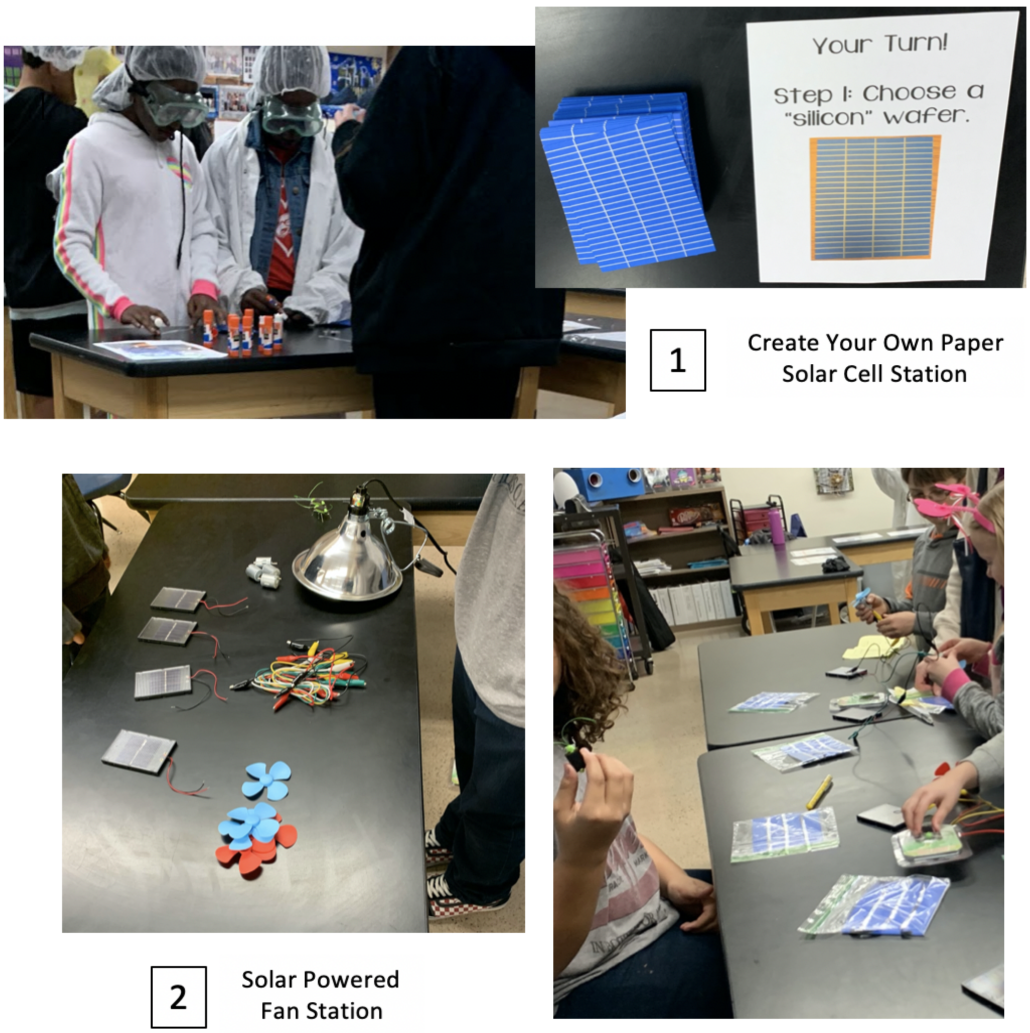
Julie reported that during the school year, “I also incorporated finding a purpose from [Jade Whipple] into a lot of discussions with my students. It's surprising to me to see how many of them have a fairy tale idea of what they want to be when they grow up rather than looking into what they love to do and finding a way to make money doing it.” Even after her school moved online in the spring, Julie reported in her final interview that she was looking for ways to use futures thinking to help her students process the situation with the global pandemic and its impacts as well as to provide “enrichment activities” to keep her students engaged with science that was meaningful to them.

Implementing STEM Family Night

In the fall following the summer RET program, I was able to observe Julie interacting with her students and their families as they participated in a school event: STEM Family Night. Julie organized this event as part of her desire to connect with the families of the students and give them opportunities to engage in STEM learning together. Teachers and volunteers set up different STEM activities around the school and Julie’s students assisted in setting up and running the activities (see Figure 6). For example, in Julie’s classroom, her students helped visitors to dress up in clean room laboratory gear and go through the process of making a paper solar cell in order to learn about how actual solar cells are fabricated.

Figure 6

Photos from Julie's School STEM Family Night



During the event, I was able to observe first-hand the rapport Julie had with her students. At one point, one of her students completed a task and exclaimed, "I did it! See I am smart!" Julie, who was just walking back into the room from checking on other stations, responded, "Finally you realize it!" Julie's response demonstrated her ongoing conversations with the students encouraging and validating their self-perceptions as students, scientists, and engineers.

I also observed how Julie was empowering her students. She gave them their initial assignments, but then expected them to just jump in and help the teachers and volunteers in facilitating the different stations and activities. She responded to questions students had and helped them when they requested it, but otherwise allowed them to lead the activities, decide on the materials they needed, get those materials from around the room, and so on. The students had created the signs for the stations, organized the rooms to ensure the best flow, and engaged with the visitors to their activities. At the end of the evening, the students working in Julie's room moved all of the tables back to their correct places, found wipes for the tables and cleaned them, and then swept the room, all while Julie was helping in other locations around the school. The flow was very similar to what Jade had demonstrated with her students during the RESET program.

Navigating Contextual Tensions

In terms of implementing her Agri-PV, or solar garden, project, Julie dealt with contextual constraints throughout the year at the school and district levels. Julie noted in the follow-up survey that "my school and district were not willing to support my initial idea, and my backup has had to be postponed due to school closures now." Julie presented the idea early in the school year, but district policy prevented her from implementing an installed garden and solar unit. Therefore, it would need to be mobile so it could be brought inside the school at night.

While Julie and Dr. Jordan worked through a possible solution to this challenge, the school administrator told Julie that because this was not something that was tested on the end of year achievement test, she wanted Julie to focus her science instruction on tested concepts until the testing was completed at the beginning of April. Then she could focus on these topics. Julie decided to implement something similar to what Abby had implemented at another school, where students would design small Agri-PV installations to either pitch to the school for the following year, or to implement at home. However, with the closure of the schools with COVID-19, she was not able to implement this project either.

Frustrated with these ongoing challenges, Julie decided to look for other teaching positions. Julie reported in her final interview in April that she had just accepted a job in another school district. As her new school district had a clear STEM focus, she was excited about the possibilities of implementing her ideas moving forward. Julie was looking forward to continuing to implement what she had learned through RESET and in becoming even more responsive to her students. Even as school remained online the following school year at her new school, the influences of Julie's learning from RESET were apparent on her class website, where the home screen included a wall of pictures of "Women and Men of STEM" that represented individuals from a variety of sociocultural backgrounds. Further, on her "About Me" page, Julie noted that "you are entering a non-judgment zone. I promise to accept and appreciate every one of you for the awesome and unique individual that you are!" Julie had followed through on her realization that her "acceptance of all" and "colorblind" statements were not responsive to her students, and replaced it with a statement of acceptance and appreciation of the students as individuals.

Case 4: Abby - Achieving RESET Outcomes

More than any of the other focal teachers, Abby came into the RESET PD having already developed a role identity as a culturally responsive science and engineering educator. When the teachers introduced themselves to each other near the beginning of the program, Abby noted that her strengths included “solving problems with innovative solutions” and seeing “the value in including others, finding strengths in other people, and really collaborating.” Abby also reported that, before participating in the RESET PD, she perceived herself as “very responsive to students' culture and their upbringing, and who they are as people.” Abby discussed her "very strong" ontological belief that partnerships and PD opportunities like the SEER summer program "are critical for our teachers to keep them staying in the profession and developing their craft and preparing the students for career and college readiness."

Abby also explained her epistemological belief that teachers needed these experiences and partnerships in order to have the knowledge to "open students' eyes, especially in a district like [ours], to engineering and technical fields to show students they can do it. Those [fields] are accessible to them." Thus, Abby’s purpose for participating in the summer program was to discover “what kind of PD opportunities and innovations, about sustainability specifically, can I learn and bring back to the teachers or directly to the students?” Specifically, Abby hoped to develop additional sustainability resources for the teachers in her district and to help students “feel empowered to design solar photovoltaics spaces within their school communities.”

During RESET and the following school year, Abby experienced the most change and growth in her role identity as a culturally responsive science and engineering educator. Two key events - Dr. Adisa's presentation and the teachers' discussion following the presentation - prompted Abby to reevaluate her self-perceptions of her responsiveness and her beliefs and perceived action possibilities related to accomplishing her goals and purposes. Abby's actions as a culturally responsive science and engineering educator the following school year were highly influenced by her participation in RESET, as she sought to be an advocate for student empowerment and a leader in challenging inequitable educational practices.

Rethinking Responsiveness

In her initial interview, Abby shared her beliefs that the best way to increase underserved students' access to and participation in science and engineering was to increase teachers' content expertise. Abby wanted to partner with science and engineering experts and provide more technical training for teachers in the specific content areas they would be teaching. These teachers and experts could then "create a pathway" for students to succeed in science and engineering courses and careers by helping students acquire the specific set of knowledge, skills, and attributes needed to be successful. Abby frequently expressed her beliefs related to a "track" or "pipeline" or "path" to college and career readiness, especially in science and engineering, and that teachers must prepare students for that path in order for students to be "successful."

In terms of the type of project or instructional materials she wanted to design, Abby explained her ideas during our initial brainstorming session:

> So, my goal is to at least start the process of getting a student group in our district to research, study and try to pursue an Agri-PV structure. So, it doesn't have to be large, it could be small. I have an interest in gardening, and I've seen the value in

having school gardens on our campuses... School gardens are popping up everywhere. Districts get it. They're supporting school gardens. There's funding available like crazy for school gardens and a lot of support. Teachers want it. So, I think gardening is a good entry point for solar… and it's a potential to take my interests and newfound love of solar…. I'd [also] like to create some lesson plans. So here [during RESET] I have the time to create lessons or organize lessons that already exist... So, I could present it to the principal and say, do you want at least a small Agri-PV installation? If the answer is yes, here's what the curriculum would look like.

Abby also wanted to interact with the YS HS and YS MS students, most of whom were either current or past students in her district, during the summer program. Abby explained, "I see myself in a position to participate [with the YS groups on their projects], continue to learn the model [of the YS programs], and then create more partnerships and more experiences for other campuses [within her district] to develop youth scholar programs." Abby's ideas reflected her focus on a teacher-centered, rather than a student-centered, approach to engaging students in science and engineering content. While well-intentioned, this focus mirrored the common hierarchical power structures prevalent in schools that can lead to the reproduction of educational inequity.

Abby's beliefs about the need for teachers to help students – especially historically underserved students – adopt and become fluent with existing, dominant ideas and practices of the science and engineering fields were apparent in several of Abby's comments in the initial interview and on the ICM (Boveda, 2016). For instance, in her response to Item 9 about whether students' parents and families had knowledge and expertise that could contribute to students' success at school, Abby wrote:

> Educators have the necessary knowledge and expertise to contribute to students' success in school. Parents that are not educators don't typically have the experience to understand the complexity of 'student success' in our schools. The school success model has changed so much since most parents were the students in a school, which I believe is one reason that we have a lack of CURRENT knowledge by parents.

Further, Abby noted that non-white students were "quite improperly" placed in special education courses, because "I believe language barriers and education disadvantage occur more frequently with non-white students, and schools mis-identify these challenges with a special education label." When responding to the question about the importance of helping students maintain their native languages or helping them to learn English, Abby responded that they were equally important, but commented, "this is an interesting question." Thus, though Abby was aware of many of the inequities of the educational system and many of her beliefs aligned with the principles of CRT, she still held deficit perspectives in regards to the support students' families could give and the benefits of being multilingual.

Influence of RESET

The most influential part of RESET for Abby came through her participation in Dr. Adisa's talk and the following teacher discussion. In her presentation, Dr. Adisa focused on how, as teachers, our identities or "self" shapes "how we see the world and our pedagogy and instructional decision making" (PPT). Dr. Adisa continued that "what we select" as teachers "enriches or dwarfs the learning experiences of our students." The remainder of her presentation focused on the ways in which teachers' choices and narratives can either be responsive and enriching, or non-responsive and detrimental. Dr. Adisa's presentation and the teacher discussion following became a significant turning point in Abby's self-perceptions, beliefs, purposes and goals, and perceived action possibilities in her role identity as a culturally responsive educator.

In talking with Dr. Jordan and I during lunch following this presentation and discussion, Abby noted a specific shift in her self-perceptions that had happened that day, "I felt like all these years I was very responsive to students.... And after today's session I'm realizing that I'm not." Abby then explained this shift in terms of her past actions and beliefs related to students' cultures and native languages:

> By doing certain things out of habit, like forcing students to appreciate English language more than their native language, I am creating this pathway that I believe I know what's better for them in their future. And instead of appreciating what their culture is, and encouraging them to grow within their culture, and within their language, and within their cultural norms, instead of trying to get them to transition to my cultural norms, that I am derailing them from potentially their ultimate success… And I'm going to give them, maybe, even a negative self-perception of who they are, that their culture and their norm is not as good as mine.

Abby adopted the metaphor of a train track or pathway to explain her recognition of what she had believed and done as opposed to her new understanding of responsiveness. Abby believed she had been responsive to students by helping them focus on English as the language which would bring them access and success. However, she now felt this was "forcing" students to "transition" onto the pathway she had created, which could potentially "derail" students from "ultimate success" and give them "a negative self-perception."

Abby explained she had been doing these things "out of habit" and a lack of awareness, because she believed that she knew what students needed to succeed in the future. In order to reach that success, students would need to adapt to Abby's beliefs and cultural norms. Abby went on to state that, "[Before today] I would've answered a survey saying 'I have no bias, everything I'm doing is fine. I've never taught in a way that's set students up in this way.' But I have."

Attending Dr. Adisa's talk and participating in the discussion following were pivotal in Abby's realization that she was complicit, albeit unintentionally, in practices that were not culturally responsive and that she did have biases and beliefs that impacted her practices as an educator. Abby went on to apply this realization specifically to her role as an advocate for students' equitable participation in STEM. She noted:

> But if you don't know who your students are, and you don't allow them to be who they are, and you don't appreciate their culture, and allow them to have their language, and allow them to grow with whatever that was, and whoever they are, and instead ask them to jump on to this track and this train, they may not ever get into STEM, because it's too much. Now they have to learn how to be someone else. And live in a different society. And why not just let them be who they are and embrace STEM? … Let them continue down that path and still show them where a STEM career could be on their own path. Not switch gears over here and

> say, "But if you do this, you can have this amazing STEM career." You can still have a STEM career. Stay on your path. Keep those fundamental, cultural aspects because it's important for diversity. It's important for a global culture. It's for all the reasons that we know it's important to have Native American students that are still Native Americans. Keep them on the path. Encourage them… And I trust in you, by educating you as a person, I give you knowledge and tools, that you're going to be successful on your own path.

Abby again used the metaphor of a track and train throughout her explanation of her new perceived action possibilities. Instead of asking students to “jump on to this track and this train” in order to “have this amazing STEM career,” Abby saw the possibilities if educators got to know their students and “let them be who they are” and “stay on [their] path.” She recognized that students “can still have a STEM career” without having “to learn how to be someone else” and that both the students and STEM would benefit from the diversity if students were encouraged to keep their culture and language and varied perspectives. At this point in the program, Abby’s focus shifted more to empowering and supporting students, and trusting in students to be successful on their “own path” if educators “give them knowledge and tools.”

In reflecting on these changes in her beliefs and perceived action possibilities, Abby stated that “I don’t know why it clicked today,” but then explained that these ideas emerged through “the discussions that we had.” Abby found that having the opportunity to have specific beliefs challenged, such as the need for students to adopt English over their native language in order to be “successful,” and then being able to process through these ideas in a critical way, with other teachers supporting or pushing against these ideas during the teachers' discussion resulted in changes.

In her exit interview at the end of the summer program, Abby reflected back on this shift, highlighting her change from a perspective of teacher "control" to one of students empowerment. Abby again reflected on her self-perception that she was being responsive, when she was not:

> I think the intent of good educators is always to be aware and to feel like we are being responsive. But I think there are habits that we get ourselves into and we're unaware of the consequences of those habits. Then I think we are instructed in certain ways that are not great for empowering students from all backgrounds and walks of life, no matter what it is. And I think there are strategies that I wasn't aware of before. I feel like if you're in this public education realm and you've stayed committed and you're in for just reasons, you feel like you have all of that. I would have said I have no need for growth in that area. The human brain is just complex, and I think it's bad habits you pick up along the way or ignorance in some areas.

Abby went on to explain that, through her participation in RESET, she had "the opportunity to listen to the strategies or even really understand yourself and some of the ways in which, as a teacher, I might not have been so aware of where my fault was." For example, Abby acknowledged that, in the past, she might have stifled a conversation or learning opportunity for a student and been "completely unaware that I was doing that or that was the wrong thing to do." Abby also explained that too often she felt she had

> to take control too much. The teacher's the leader. You lead the students through the lesson…. I think of periods of time, thinking of only my objective, of getting through the lesson and the content in a timely manner, instead of having a real grasp and understanding of all the different backgrounds my students come from and are part of their lives that are influencing their learning at that point in time.

However, Abby explained that, moving forward, she wanted instead to be guided by the question: "How can I be empowering students from all different groups in their learning and growth, not just for the science, but also socially and emotionally?" This broader focus on student achievement is one of the attributes of CRT (Gay, 2018).

Becoming an Advocate and Change Agent

In addition to experiencing a shift in how she understood CRT, Abby also became more passionate about being an advocate for student-led projects and a change agent who questioned and disrupted inequitable practices in her district. At the beginning of the summer program, as she introduced herself to the other teachers, Abby noted that her biggest challenges as an educator were "staying in my lane," or just focusing on her specific assigned responsibilities, and "keeping my opinions to myself." Abby explained that "if I think I'm right or I think it's good for kids, then usually I stick with my opinions." However, for things that are not in her "lane," she has had to "learn to roll with it."

Her responses to Item 18 on the ICM reflected this stance as well. When asked if it was part of teachers' responsibilities to challenge policies and practices that maintained social inequities in schools, Abby responded that it was "somewhat part" of teachers' responsibilities. She clarified through a written comment that "Yes, it is, but the teacher must also follow policy. Unfortunately, many administrators do not support teachers challenging anything." Abby seemed to have accepted this as the reality of being an educator.

Influence of RESET

However, again after Dr. Adisa's talk and Abby's shift in beliefs and perceived action possibilities, Abby began to focus on taking additional action as an advocate for students and as a change agent within her district. Abby noted in one of her written reflections, "I'd like to think I am in a community that needs my advocacy and enthusiasm for sustainable solutions to current problems." Several events during RESET helped her refine her plans for how to do so.

In her exit interview, Abby shared several things she was thinking about in terms of how to implement more responsive practices in her own instruction and as she prepared other teachers. Abby wanted

> to have a more dynamic flow in the learning…and consciously think about, "do I have an aspect of culture [in this lesson]? Are the students discussing their cultural backgrounds? Are they discussing themselves? Are they investing themselves? Am I providing that in the learning environment? It's not just about "can you regurgitate the answer?" but "have I developed your skills to be a better learner and contributor to this?"

In order to foster this kind of environment, though, she knew she needed to get to know the students and build relationships with them so the students are "comfortable enough" to talk about themselves and their cultures.

Abby wanted to have more "casual conversation with a student to understand their cultural norms as well." Abby gave the example of a comment Fernando made during one of the teacher discussions that, "in my culture, I sit and listen." Fernando was explaining why he had not made many comments in our discussions and how he was used to waiting for a pause in the conversation, which did not necessarily happen very often in our discussions, given other teachers' styles of communicating. Abby explained that Fernando's comment was "just such an awakening moment for me of how this happens in the classroom. [But] maybe the student never speaks up to say, 'This is why I behave in this way. This is how I learn.'" Therefore, teachers need to create opportunities for these conversations.

Abby also mused that "maybe I should be teaching in a way where I am observing the learning that's happening instead of always evaluating." She explained that it was necessary to evaluate, but observing more could help her "try to understand what's happening and try to understand how students are engaged." Abby wanted to use these ideas to counter the narrative she often heard from teachers of "just let me get through the lesson. If students didn't learn, it's because they didn't care. They weren't engaged." Instead, Abby wanted to focus her own practice and support teachers in asking, "What can we do in the classroom to facilitate learning for all students… so that everyone's more aware and we are all more sensitive to [students'] learning styles and cultural differences."

During one of our discussions with Jade after teachers had observed her for the second time, Abby commented about the diagram and activity Jade had used with the YS

MS to help them to discover their purposes by thinking about passions, professions, vocations, and missions:

> I loved that [the lesson] answered a question [the teachers] had that we talked about previously, about how do we show the students in an authentic way why they should care about science education and why they should personally invest in it if they come to us saying, "I don't really like science. I don't think I'm going into a science career." That lesson helped me, at least, see how I can very purposefully address that without just saying, "You should learn science because you never know. You might decide you want to."

Abby was able to connect Jade's activity to a past discussion amongst the teachers, which I referred to in the section about Tom, and perceive a new action possibility for helping students discover ways in which a STEM (or other) course or career might be a good fit for them.

While Abby's fundamental plan for her Agri-PV project and instructional materials did not change over the course of RESET, her focus became much more student centered. Abby explained that through interacting with the YS MS and HS, who were working on self-selected and self-directed community engineering projects, she realized that

> by allowing students to identify the problem that is relevant to them in their community, you are providing access to the idea that their problems are worthy of the engineering design process solution…and an opportunity for students to see that engineering affects their daily lives and the lives of people they relate to.

Thus, in Abby and Julie's lessons, they specified the goal to create a solar garden, but left the rest open ended so that students could create designs and navigate challenges based on their specific strengths and needs. In her exit interview, Abby explained that in "six month's time" she wanted to reflect on "this is what I did with the lesson plan that [Julie and I] created. This is what I did with [establishing] partnerships. This is what [these actions] did to empower others to find their own learning opportunities."

In addition to discovering new action possibilities for empowering students, Abby also focused on ways she could facilitate change within her district based on her role identity as a culturally responsive teacher. After Dr. Adisa's talk, she explained that now that she had recognized some of her misconceptions about responsiveness and advocating for students, she was asking herself:

> What do I need to be doing differently? Now how do I fix it? And how am I going to take this back to [district] teachers and say, "Look. If I'm doing it, I have a feeling a lot of you are doing it as well." Because I've ...been reaching out and looking for information for years and years and years now. And I've taught in Title I schools, and I'm still committed. But, I wasn't getting it. I'm still not getting it. I'm part of the problem of why we don't have more students in STEM careers.

Now that she had become aware of how she "wasn't getting it," in terms of understanding her own bias and inequitable practices, Abby felt that other teachers in her district, especially those who looked like her, had similar issues. Abby was concerned that her district did not have a director of diversity and inclusion like the district Dr. Adisa works for, and she was wondering why, and why "when I picture our middle school science teachers, I see a lot of white males." Abby noted in her written reflection after Dr. Adisa's talk:

> It is important for me to ask my administrators to study data within [our district] so we can identify where our cultural biases are and then design steps to build equity. We can't resolve the problems if we don't know ourselves.

Abby recognized the importance of speaking up and explicitly looking for instances of bias and inequity within the district. Abby had come into the program thinking that she had no bias and was responsive to her students, but had realized that she was "part of the problem."

Abby wanted to spread awareness and spur changes. Abby acknowledged that, in regards to inequitable practices that result in many groups being underrepresented in science and engineering,

> We say sometimes, "Well, it's just a lack of access." Eh, maybe it's more than that. Maybe there's people that are actually hindering learning, not just lack of access. Maybe we're doing things to make certain groups feel like they don't know. When it's not, they don't know. They just don't have the opportunity to share or [their cultures and strengths] haven't been reinforced.

Abby then shared a specific example of how she planned to intentionally confront unjust educational practices:

> [Teachers] are just told "You're going to do this. You're going to stop the girls that are speaking in Spanish on their own time, and having a discussion and tell them that they need to use English." And now I am going to walk away from this and say, "That's not okay. No, actually, that's not okay." We can still encourage

> the learning of the English language, and should, absolutely, but there needs to be a balance and if we're not meeting the students where they're at, culturally, with their language, and their values, and their norms, then it's really going to be difficult to get them to buy into a STEM career. Because they're going to be overwhelmed with trying to become something that they're not, instead of seeing how they can stay true to themselves, and still have a STEM career. There are jobs out there that will actually appreciate you, in your diversity.

Abby's ICM response at the end of the program also reflected this change, in terms of teachers' responsibilities to challenge policies and practices, Abby indicated that it was "very much a part" of their responsibilities, a shift from the beginning when she felt it was only somewhat part of their responsibilities and when they should not challenge things because administrators would not support it.

At the end of the summer program in her exit interview, Abby shared that through the RESET PD:

> I feel empowered and educated and I feel supported and I feel like this is just the beginning of a partnership and a relationship [between her and those who had been in the summer program]. I feel like this group has invested in me personally to prepare me and help me through whatever that end result is as an educator in my community, in my classroom, my schools. And to see the whole group participating in that way is nice. It helps me see, what does a successful five-week education unit look like when we see our students for an hour [each day]? We only have these short interactions, but ultimately you do have [students] for an extended period of time. So, education is possible even in complex areas where

> not everyone has all the knowledge in certain ways. It's okay. Work as a team, create objectives, contribute, let it be a learning experience for your students. Also, I don't know if I've had such an opportunity in my past PD to really model, how do you empower students to own their learning to be a part of the process?

Abby's perception of her experience in the RET generally and RESET specifically was that it allowed her to see a model of how to "empower students" as well as to experience and feel that empowerment herself, through the support of the group and the relationships and partnerships built during our time together.

School Year Actions

During the following school year, Abby continued to work on several of the projects begun during the summer program, both because of her role supporting teachers and students, and her increased desire and perceived action possibilities for doing so. In her final interview during the school year, Abby connected back to her focus on empowering students and supporting them on their own paths:

> I think as long as we transform how some of the teachers are thinking, or even our academic coaches or our principals, if we can say, "Wait. When you have an opportunity for a new something on your campus, please step back, look at what it is and see if there's a way you can involve the students." If we could do that with every decision that we make and all the new opportunities, even that shift would be huge. But it's really hard for some school districts and schools to do.

Abby facilitated this type of thinking with teachers and administrators in several different projects, highlighted here.

Supporting the YS HS Solar Pavilion Team

Abby began the summer program with the expectation of working with the YS HS who had designed a solar pavilion in a previous summer, pitched their idea to Abby's district, and had received preliminary approval. The YS HS wanted to get their solar pavilion built at one of the two middle schools students in their group had attended, but they were working on fundraising and working through the logistics of getting the pavilion built. As Abby participated in RESET, she committed herself more fully to supporting this group of students to get the pavilion built in the district, to become their advocate. Abby consistently attended the Zoom meetings arranged by these students throughout the year, but not in a facilitator or leadership role. She frequently asked the YS HS students what they wanted to do moving forward and let them lead the project. She also attended district meetings and presentations with the students.

Abby explained in her final interview during the school year that one of the administrators in the district was

> skeptical of - not of solar or the project - but of the amount of time and energy necessary to bring this [solar pavilion] to light and whether it was good use of district resources... However, [that administrator was] the one that finally gave the okay for the district to incur the costs of getting the water and electric to the pavilion… That is such a huge sign and success, because that means she in, and she's not going to spend those dollars somewhere else.

While Abby was monitoring the approval process at the district level, the students were doing the work of creating scale models of the pavilion, developing and presenting the budget for the project to the school board, and meeting with a variety of possible sponsors or contractors. This combination of student work and passion in partnership with Abby and Dr. Jordan, resulted in getting the project approved, and eventually in the project being funded by the district.

Abby reflected on the importance of the work the YS HS students were doing for the students, the district, and the community:

> It's such critical work - what [the solar pavilion team] is doing. It's not really about just this [solar pavilion] project, but what [the students] are feeling for their school and for their communities. It shows people the possibilities of really engaging kids and creating opportunities for engineering-based relevant learning in these spaces. What these spaces can do for their school.

Abby found that supporting the Solar Pavilion team through the ups and downs of their project helped her as she began the Agri-PV project with another group in the district.

Facilitating an Agri-PV Project

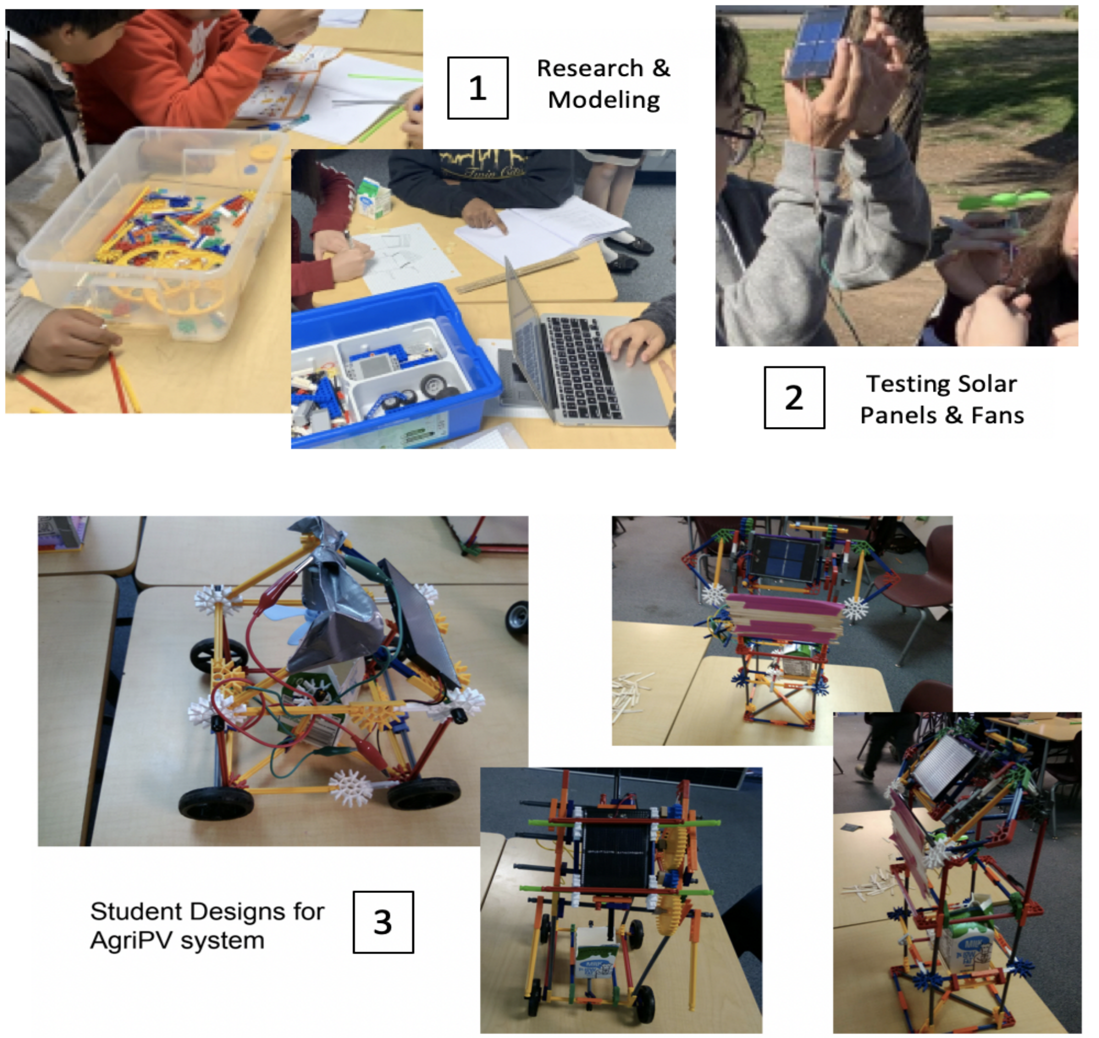
Just before the beginning of the school year, Abby chose a school within her district that she felt had the right combination of factors to want to take on an Agri-PV project. It was a newly formed school, and the principal was excited about the possibilities of a solar garden. At first, the principal wanted to "just build it" and "it'll just be here and kids can see it." Abby explained that she told the principal: "That's not what we're trying to do. We're trying to make a project based learning experience, which means the kids are going to be a part of the whole process." As she began meeting with the administration and teachers to gauge their interest and create buy-in for the project, the group became really excited about the possibilities.

The seventh grade teachers agreed to engage their students in this process throughout the school year. Abby planned to be very involved in the project. However, in October, her district administration changed Abby's role from a focus on STEM teacher PD to "more of an administrative and partnership development role." Abby was able to navigate this role by continuing to coordinate the implementation of her Agri-PV curriculum plans and other projects, while finding others to do most of the work in the classroom. For example, Abby partnered with graduate students in a course Dr. Jordan was teaching, and these students did "most of the detailed lesson development and teaching." Abby also met with several community groups, including an engineering association and a sustainability alliance. These groups agreed to provide time and resources to support the project.

In the fall, the students built the garden boxes for their solar garden and filled them with soil. They then moved on to designing the solar installation to go around the garden box. On the day in late January when I visited the school with Abby to observe, the seventh grade students had just completed construction of models of their proposed designs for the solar garden (See Figure 7). Abby had recruited several engineers to come and hear the students' pitches for their designs and give the students feedback. The engineers rotated between the three classes of students working on the project and engaged in substantive discussion with the students about their designs. The engineers asked student to explain certain aspects of their design and pointed out things the students may want to consider as they worked to improve and ultimately select a design for their installation. The students had the opportunity to be involved in meaningful, collaborative, real life work.

Figure 7

Photos from Abby's Agri-PV Project Enactment



The students involved in the Agri-PV project continued to move forward with their designs for the solar garden. In the early spring, they were researching the types of plants they wanted to include in their garden and ordering the seeds for these plants when the school was closed due to COVID-19 and the work on the garden stopped. However, when the school fully reopens, the teachers and students plan to continue the project and have a functional garden with a PV installation to use at their school. In her final interview, Abby explained:

> The good thing about the Agri-PV is that because it was a new project and I have learned so much from the challenges with the solar pavilion project, I was able to really create the buy in, create the ownership from the school, and gain the interest of the teachers and the administrator and an academic coach very early on… I was able to say “It's just a great project. A lot of the resources and work are going to be a collaboration, which means you don't have to try to figure it all out on your own, which is great for any project based learning experience. You're going to have advice and assistance and guidance.”

Abby found that the teachers and administrators were excited to engage their students in this type of learning, especially since they would have the support of others and didn’t have to “figure it all out on [their] own.”

While both the solar pavilion and Agri-PV projects had many successes, Abby cautioned that when trying to implementing these culturally responsive science and engineering projects:

> Funding is always an issue. So many of us in education try to support authentic project based learning activities and student-generated solutions on school campuses. Most of our projects lack funding to support final construction. Funding is limited likely because the process of generating ideas and solutions to space challenges typically occurs at the district level or outside of the classroom environment.

So, while she was experiencing success with the initial implementation and design work the students were doing, actually getting the students' designs constructed and functioning continued to be a struggle.

Championing Other Projects

In addition to working with the Solar Pavilion Team and facilitating the Agri-PV project, Abby continued to support Tom's project, helping him connect with the engineering students at the university. Abby also facilitated a partnership between the district and a tree planting program "to restore access to healthy tree canopy coverage in our underserved school community." Abby reported that through this project, the district and community worked together to "plant over 40 trees and shrubs on two elementary school campuses." Further, the

> American Forests Trees Equity program brought to our attention that a skilled workforce is fundamental to helping care for these trees. We also learned that [one] neighborhood [in our district], with its high tree canopy need, tends to also have the highest unemployment. Through our partnership, students [at the school in this neighborhood] are being exposed to tree care 'best practices' by signing up for an AVID classroom job as an Arborist and through classroom instruction on how to care for their newly planted on-campus trees and shrubs.

Abby was impressed by this project, where students did not just plant trees. Instead, provisions were put in place for students to learn about the trees and how to care for them, providing meaningful connections and opportunities for engagement at school, while also providing training that could be useful in the community and for future careers.

In her follow up survey at the end of the school year, Abby summarized her commitment to her culturally responsive science and engineering educator role identity by saying,

> It is my hope that through my effort to improve access to STEM content that is both relevant and representative, supports mentorship and relationship development, and builds and maintains high expectations, I will help to build students' science identity without undermining other distinct visible and invisible attributes of identity, such as culture, race, gender, and ability status.

The shifts in Abby's beliefs, self-perceptions, and purposes and goals that were evident during the RESET PD remained central to Abby's work through the following school year as Abby sought to implement many of her perceived action possibilities.

Discussion of RQ1 Findings

Looking across the findings of each of the four teachers, I discovered five main patterns or themes related to the first research question about how participating in the RESET PD influenced teachers' role identities and actions as culturally responsive science and engineering teachers. The first three themes focus on the influence of RESET on teachers' role identity systems in terms of (1) sustaining their professional purposes and goals, (2) evaluating their self-perceptions as related to CRT, and (3) expanding their perceived action possibilities for the following school year. The final two themes focus on (4) teachers' adoption of the attributes and practices of CRT and (5) their perceptions of RESET as responsive to their teacher identities. I discuss each theme in the following sections. I then discuss how these findings will impact future iterations of the RESET PD in the following chapter.

Sustaining Purposes and Goals

Across the RET program generally and RESET specifically, all four teachers' goals and purposes related to their role identities as culturally responsive science and engineering teachers largely stayed the same. Dean wanted to find ways to teach through his students' talents or strengths. Tom had few goals specifically related to being culturally responsive. Julie's goals centered on supporting students and establishing a positive learning environment for all of her students. Abby wanted to support teachers and students in her district in ways that would foster underserved students' increased participation and success in STEM.

Because their purposes and goals persisted throughout the program, it was the three teachers who found a specific connection between a key event or concept in RESET and their goals who were most influenced by the RESET PD, even if this connection countered their existing self-perceptions, beliefs, or perceived action possibilities (Garner & Kaplan, 2019). For example, both Julie and Abby connected specific beliefs and practices they had been using that they had not realized were actually detrimental to many of their students through Dr. Adisa's presentation and the subsequent teacher reflection and discussion (Milner, 2011; Utt & Tochluk, 2020). Dean found a way to process and communicate about his goals through the concept of students' funds of knowledge (Sias et al., 2016) and Jade's shared action possibilities related to funds of knowledge.

Tom's primary professional goal was actually to move to an administrative position. He was not able to make connections between this goal and the principles of CRT. In hindsight, knowing that this was Tom's professional goal, I should have scaffolded more of these connections as part of the RESET PD (Garner & Kaplan, 2019). Further, because of the strong beliefs Tom held in relation to equity and the fact that he was most influenced by how Jade's students viewed her, it might have been more influential to emphasize the importance of cultural responsiveness and actively disrupting inequitable educational practices, policies, and beliefs in being able to get a job as an administrator.

Re-Evaluating Self-Perceptions and Beliefs

The second theme, related to the first, was that when teachers were able to make connections between their purposes and goals as culturally responsive science and engineering teachers and aspects of RESET, these connections generally resulted in shifts in the teachers' self-perceptions and/or ontological and epistemological beliefs (Kaplan & Garner, 2017). The critical discussion component of RESET played a key role in these shifts. For example, when Dr. Adisa discussed how being "colorblind" negatively impacted students' perceptions of their cultures and identities, Julie recognized this as a practice she had consistently used, discussing with her students each year that their race, ethnicity, culture, and so on, "did not matter" because everyone was accepted and a part of their classroom community.

Julie realized through the presentation that these statements actually devalued students' backgrounds. Then, as Julie discussed her new awareness with the other teachers after this talk, Julie had a chance to hear from Bianca, who used her personal experiences in high school, when she went home and told her mom that she "wanted to be White" to help Julie better understand and later change this practice within her classroom. Abby went through a similar process, though on a broader scale rather than in relation to one specific perception or belief. Because teachers had several opportunities to participate in these discussions and a five-week PD experience to get to know one another, the teachers became more comfortable with sharing their own experiences and pushing back on each other's ideas, an important action related to CRT (Gay, 2018).

While Dean was not as active of a participant in these discussions, preferring to listen and process, many of the notable changes in his comments and responses on the ICM at the end of the program came through points that the other teachers highlighted in the discussions. During these discussions, Tom also frequently shared his beliefs or provided counter arguments for some of the principles of CRT and more equitable educational practices. This often spurred longer discussions between the teachers, giving most of the teachers opportunities to hear a variety of perspectives on issues of social justice and equity. Though Tom maintained his beliefs, he did acknowledge by the end of the program that if wanted different results, he needed to make changes to some of his classroom practices. Unfortunately, though, it did not appear that many of those changes took place.

Expanding Perceived Action Possibilities

All four of the teachers reported action plans at the end of the summer program that included concepts from RESET and that had expanded beyond their ideas about what they could do at the beginning of the program. This seemed most often to be tied to interactions with Jade and the YS MS and HS students. All of the teachers at least talked about their desire to make their instruction more student-centered and student-led and about giving the students much more choice in their projects, forms of representation, and so on. What they had a harder time with was understanding how Jade had gotten to that point and the logistics that underlay all of that. They spent much of their time interviewing the YS MS students and in their second discussion with Jade asking these types of questions, highlighting the need for even more scaffolding in those areas.

Further, the discussions that the teachers had during and after their own experiences in Solar Cell 101 allowed the teachers to compare and make sense of their own experiences in the lab and then connect these experiences to the classroom, even though they would not be able to replicate the actual fabrication of solar cells (Southerland et al., 2016). Several of the teachers discussed how their experiences helped them to reconsider how to incorporate science and engineering into their classrooms. For example, Abby explained how something unexpected happened with one of the solar cells her group was creating. Instead of just continuing on in the fabrication process, "we decided to sacrifice one of our wafers, not continue on, leave it where it was, because we wanted to see what the structure was going to look like right here at this phase" because this was something that even the graduate student engineering mentor had not seen before. After sharing this experience, Abby noted that those in her group - which also included a high school student, an undergraduate science major, the graduate student engineering mentor, and an engineer - came from a "variety of academic levels" as well as "from different viewpoints" and that "the diversity of our group...[was] very helpful" to engaging with this situation.

Building on this perspective, Bianca commented on the specific experience, noting that the group and engineering mentors were willing to interrupt what the group was doing in the solar cell fabrication process because "that's what drives [the engineering mentors]: knowledge. They want to learn and to investigate, and to find an answer or explanation to what's happening." Julie added, "Which is kind of the common theme why we're all here...we want to understand. So, when we pull that common theme together, maybe then that's 'Okay, hit the brakes. Let's figure it out then.'" Both Bianca and Julie pointed out a specific approach the engineering mentors took - stopping the process to figure out what was happening - which was unlike what they often experienced or implemented in classrooms, where completing the process often took priority over learning from the process.

From these comments from the other teachers and all of their connections to their experiences in the lab, Abby concluded,

> Maybe in designing lab experience for students, one thing we don't do well enough is allow the inquiry process. As the teams [of students] are working and come to a question they can't answer, they go this path: [The students] try to find the answer to that question rather than [the teacher saying], "We'll get to the answer later, just keep going in your steps." Maybe [the students] would feel more empowered to learn and maybe they would enjoy science more.

Abby was able to translate her own experience in the lab to something that could be useful for her in the classroom and in helping other teachers implement more inquiry learning (Brown, 2017). It was through the discussion and the insight of the other participants, though, that she was able to make this connection.

Adopting Principles of CRT

Often because of their interactions with Jade and the YS MS students, in their exit interviews at the end of the program, all of the teachers mentioned the principle of empowering students (Gay, 2018) through giving them more choice, more opportunities to show their learning and engage in projects that were meaningful to them and to their communities, and providing opportunities for students to use their voices to advocate for the things that were important to them (Calabrese Barton & Tan, 2019). As Julie explained, "I think the other thing I got really strong out of this [program], especially seeing the youth scholars, is when we empower our kids and give them a voice, there is nothing more powerful."

Different teachers also focused on some aspects of the other principles of CRT. For example, Julie sought to "build bridges of meaningfulness between home and school experiences" (Gay, 2018, p. 37) through organizing a STEM family night. Dean planned to engage his students in knowing more about their cultural heritage through their Native American projects. The projects that Abby facilitated during the school year emphasized aspects of being comprehensive and inclusive, and specifically "holding students accountable for valuing learning as communal, reciprocal, and interdependent" (Gay, 2018, p. 39) as they engaged in group engineering design projects for their schools and communities.

While I did not see extensive evidence of teachers implementing the principles of transformative and emancipatory CRT, I did see some of the beginnings of this type of work, especially in terms of helping students to challenge traditional representations and perceptions of who can be scientists and engineers and becoming more active participants in shaping their own learning. And while COVID-19 has disrupted many school practices and teachers abilities to engage students in the types of engineering projects they had begun during the school year, my most recent check in with each of the teachers during January (a year and a half after their participation in RESET) indicates that they are anxious to continue this work as soon as they can. In fact, Abby even used the current challenges to help the YS HS students finally get full approval and funding for their Solar Pavilion project, as outdoor learning spaces are so needed.

Modeling a Responsive Environment

RESET was set up to model several aspects of responsive teaching, especially through encouraging multiple viewpoints and critical discussions where teachers could push back on each other's ideas without attacking the person. I sought throughout RESET to position myself as the facilitator who would "pass the mike" to those who are experts in various areas, but then give the teachers the space to process these ideas and apply them to their own identities as mid-career K-8 science and engineering teachers. Abby specifically commented on how she felt RESET had been responsive to her and helped her to feel empowered as a teacher. Julie also mentioned the empowerment of learning more about engineering and best practices for implementing more science and engineering with her students (Brown & Crippen, 2016).

Dean's situation was unique in a variety of ways, and I should have adapted RESET to be much more responsive to his sociocultural identity and contextual constraints (Edwards et al., 2019). Dean had been teaching third grade, but found out he would be moving to teach second grade the following school year. With Julie moving from teaching fifth grade to seventh and eighth grade, Dean became the only elementary school teacher in the program, and our first RET teacher of a lower elementary school grade level. Dean was also the only teacher staying in university housing during the program and not returning home each day, because he lived several hours away. Thus, Dean was unintentionally isolated in many ways within the program. While Dean was very gracious about these failings and insisted he had a great experience despite these factors, when pressed for suggestions for improvement in the program moving forward, Dean replied,

> I guess it would've been - since I'm an elementary teacher and most of the teachers were from around here - I was thinking maybe it would have been good if I had someone from my same district, like in high school level or middle school level to participate with me, so that we can collaborate on how we can make it work through high elementary, middle and high school.

Because of the limited number of teachers, we could include in the SEER program each summer and specific requirements from NSF, we had not been able to admit all of the applicants we wanted to, including other teachers from Navajo Nation. However, in the future, Dr. Jordan and I will work to address these issues of isolation to make sure that we provide better support for our teachers coming from farther away. Further, while I selected materials, resources, and speakers that represented a variety of cultures, races, and viewpoints, I did not include anything specifically from a Navajo perspective. So, along with the teachers, I learned much about improving my actions as a culturally responsive science and engineering teacher educator. The following chapter focuses on this in depth.

CHAPTER 5

RQ 2 FINDINGS AND DISCUSSION

Having detailed the findings for each of the four focal teachers and across the teachers in relation to RQ 1, I now present and discuss my findings relative to the second research question: What do we learn about how to integrate a focus on CRT as an inherent part of a science and engineering PD? This chapter is organized into two main parts, with several sections in each. The first part of the chapter includes an overview and brief discussion of the RQ 2 findings. It includes an overview of the specific design and process conjectures that guided this study and the findings related to the design components and conjectures of this study. As is typical in DBR studies, which are designed to be iterative (McKenney & Reeves, 2019), the second part of the chapter includes a discussion of the findings for RQ 2 in terms of their implications for the next iteration of RESET, which I refer to as RESET 2.0. It also includes a discussion of the findings from both research questions and their implications for the general scholarship related to culturally responsive science and engineering PD. At the end of the chapter, I provide a conclusion to the dissertation study, synthesizing across the findings.

Conjecture Maps

As discussed in the previous chapters, conjecture maps are "a means of specifying theoretically salient features of a learning environment design and mapping out how they are predicted to work together to produce desired outcomes" (Sandoval, 2014, p. 19). Creating conjecture maps as part of this DBR study allowed me to represent the design of RESET before implementing it (see RESET Conjecture Map 1 in Appendix A) and as I made adaptations to the design while enacting RESET (see RESET Conjecture Map 2 in

Appendix D; Sandoval, 2014). The use of a series of conjecture maps to document changes across the designed iteration provided a record of the decisions made in response to various and complex internal and external influences on the RESET PD intervention over time (Lee et al., 2018; Svihla & Reeve, 2016).

I also used the conjecture maps to hypothesize the relationships between specific design features, processes, and outcomes (Boelens et al., 2020). The overall, high-level conjecture guiding the design and enactment of RESET was that

> Integrating a focus on the principles of CRT as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

As discussed in Chapter 3, I chose not only to make overall design and process conjectures about the design of RESET, but also to make specific conjectures related to each of the enactment processes. In the next several sections, I detail my findings related to both the overall and the specific conjectures by enactment process.

Design Conjectures

Through design conjectures, I hypothesized how the key design features of RESET would generate the enactment processes. My initial, overall design conjecture for the RESET PD intervention, first introduced in Chapter 2, stated that

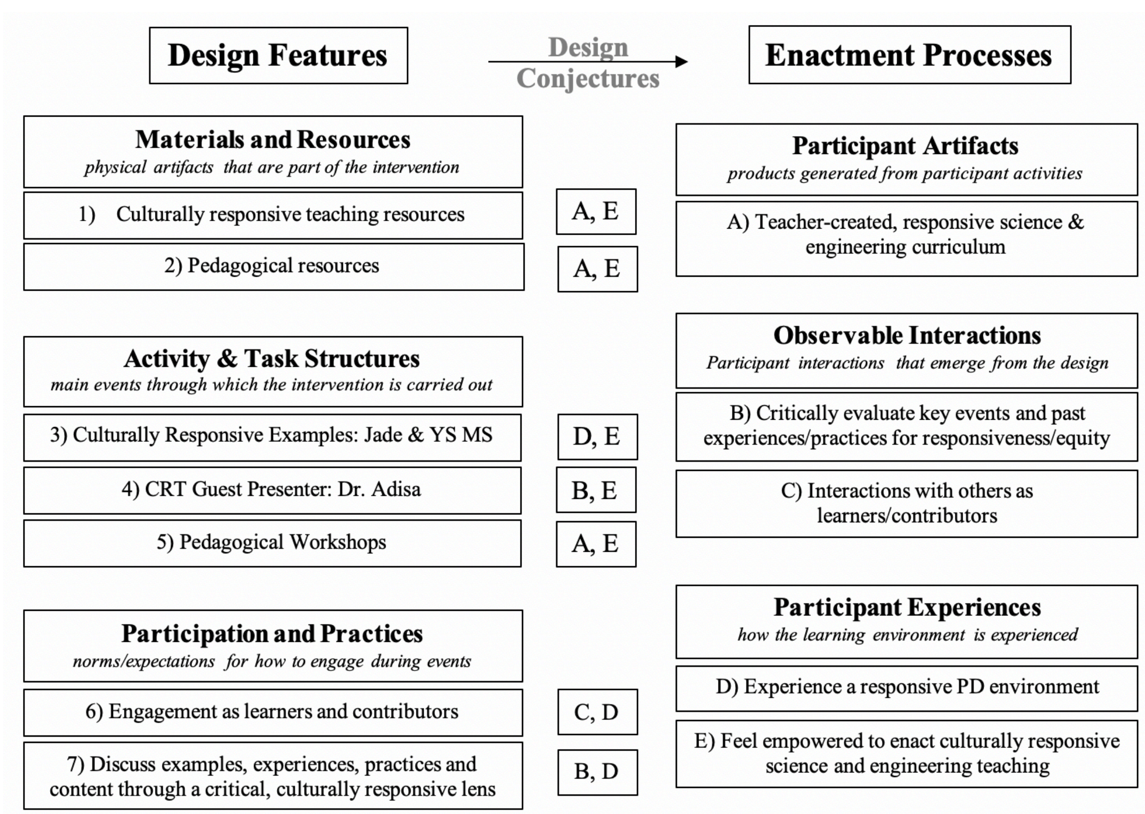
> If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and

social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum.

In addition to this overarching design conjecture, I also made a specific design conjecture related to the targeted connections between the RESET's design features and specific enactment processes. Like Boelens et al. (2020), in their conjecture mapping of a teacher education course to support adult learners with accomplishing open-ended tasks, I only included only the one or two main targeted connections as part of the analysis, recognizing that other interactions between the design features and enactment processes also likely contributed to the outcomes. Figure 8 displays part of RESET Conjecture Map 2, including these connections between the design features and enactment processes.

Figure 8

Hypothesized Connections Between Design Features and Enactment Processes



As shown in the figure, I hypothesized that Design Feature 1, the CRT resources shared with teachers, would help teachers achieve Enactment Process A, creating a responsive science and engineering curriculum, and Enactment Process E, feeling empowered to enact culturally responsive science and engineering teaching. Table 10 lists the specific design conjectures for each of these connections, again, grouped by enactment process (EP).

Table 10

Specific Design Conjectures by Enactment Process

EP	Design Conjectures
A	Including shared CRT resources and pedagogical resources and workshops in RESET will help teachers create responsive science and engineering curriculum.
B	Attending presentations about CRT and discussing examples, experiences, and pedagogical strategies will help teachers critically evaluate these examples, experiences, and pedagogical strategies for responsiveness and equity.
C	Observation of and participation in CRT examples and engagement as both learners and contributors during RESET will help teachers interact with other teachers, YS MS and HS students, and SEER staff in nontraditional ways, with a less hierarchical structure.
D	Teachers engagement as learners and contributors and discussions of events in RESET through a critical, culturally responsive lens will help teachers to experience a responsive PD environment.
E	When teachers have access to resources supporting culturally responsive science and engineering pedagogical practices, learn about CRT and observe these practices being enacted it will help them feel empowered to enact culturally responsive science and engineering teaching in their own classrooms.

Process Conjectures

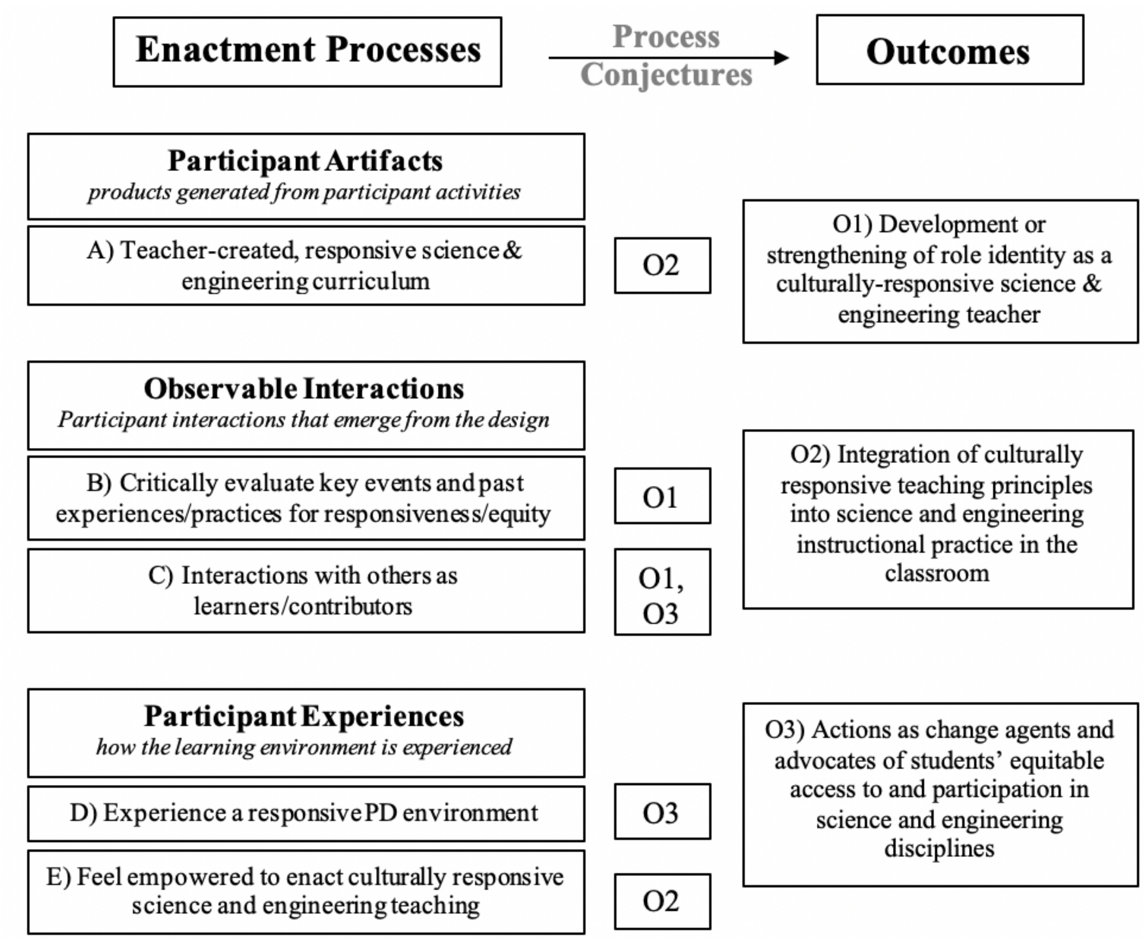
Through process conjectures, I hypothesized how the enactment processes of RESET would lead to the three targeted outcomes. My overall process conjecture for the RESET PD intervention stated that

> If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally-responsive science and engineering teaching in their classrooms.

In addition to the overarching process conjecture, I made specific process conjectures related to the targeted connections between RESET's enactment processes, should these occur, and the outcomes that were the ultimate goal of the RESET PD intervention. As with the design conjectures, I only included only the one or two main targeted connections as part of the analysis. Figure 9 displays the portion of RESET Conjecture Map 2 which includes the hypothesized connections between the enactment processes and outcomes.

Figure 9

Hypothesized Connections Between Enactment Processes and Outcomes



As shown in the figure, I hypothesized that teachers creating a responsive science and engineering curriculum (Enactment Process A) would lead to teachers' integration of CRT principles into their science and engineering instructional practice in their classrooms (Outcome 2). Table 11 lists the specific process conjectures for each of the connections displayed on the conjecture map by enactment process.

Table 11

Specific Process Conjectures by Enactment Process

EP	Process Conjectures
A	If teachers design a science and engineering curriculum that is responsive to their students, they will integrate CRT principles into their instructional practice in the classroom.
B	If teachers critically evaluate examples, experiences, and pedagogical strategies for responsiveness and equity, then they will develop or strengthen their role identity as a culturally responsive science and engineering teacher.
C	Teachers interacting with other teachers, students, and staff as learners and contributors will foster teachers' role identities as culturally responsive science and engineering teachers and actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines.
D	If teachers experience a responsive PD environment, then they will engage in actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines.
E	If teachers feel empowered to enact culturally responsive science and engineering teaching in the classroom, they will integrate CRT principles into their instructional practices.

Findings Related to the Conjectures

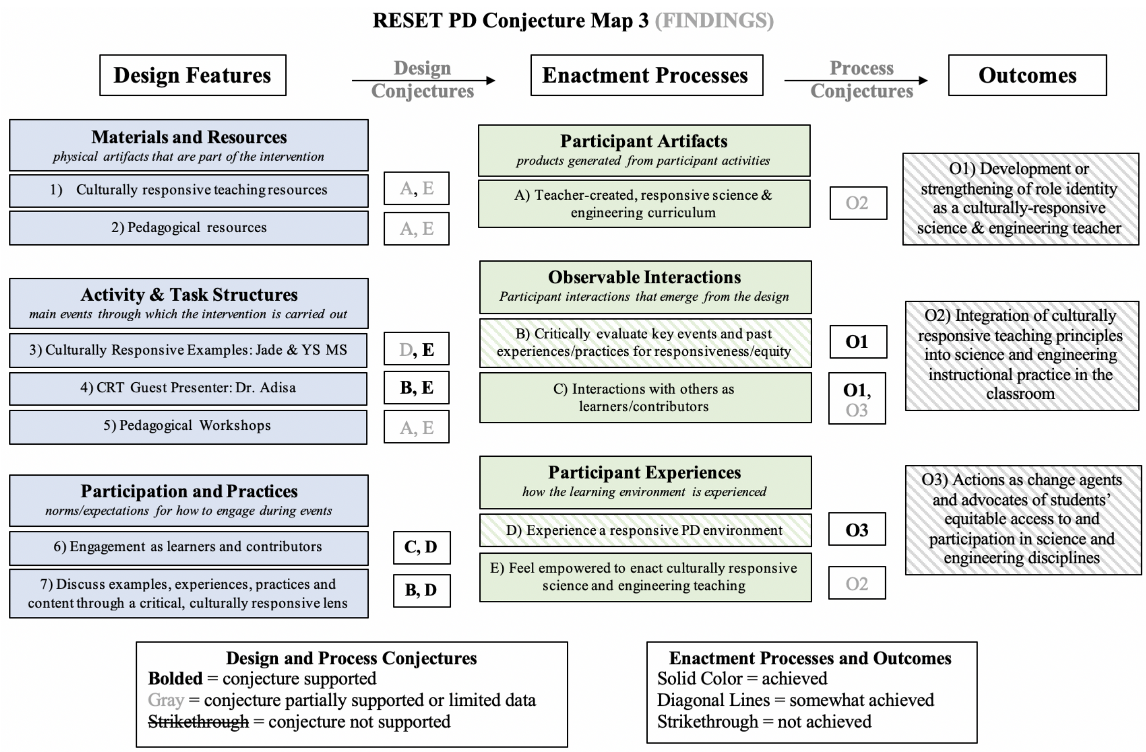
To address the second research question regarding what was learned from this iteration of RESET about how to integrate a focus on CRT into science and engineering PD, I used a combination of the formative evaluation criteria proposed by Nieveen and Folmer (2013) for DBR and the conjecture mapping analysis process used by Boelen et al. (2020) in their study. As Nieveen and Folmer (2013) argued, in order to evaluate a designed intervention for quality during and after the implementation of an invention, researchers should focus on both the expected and actual practicality of the intervention and its expected and actual effectiveness. The first two versions of the conjecture maps and specific conjectures detailed the expected practicality, or how usable the intervention would be, and the expected effectiveness, or how the RESET PD was expected to foster the desired outcomes. The conjecture map analysis then focused on the actual practicality of the teachers using what they learned in RESET in their roles as teachers and educators. It also focused on the actual effectiveness of RESET in achieving the targeted outcomes.

I looked within and across the four teachers' cases to determine whether the practicality of each of the design and process conjectures had been *supported*, *partially supported*, or *not supported*. I also examined this data to determine whether and to what extent this iteration of RESET was effective, in terms of whether the teachers *achieved*, *somewhat achieved*, or *did not achieve* the targeted enactment processes and outcomes. Through this analysis, the objective was to evaluate the conjectures, processes, and outcomes in the service of planning future iterations of RESET and adding to the scholarship on culturally responsive science and engineering PD (Boelens et al., 2020).

RESET Conjecture Map 3 (see Figure 10 or Appendix M for a larger version) depicts the findings of this analysis. These findings are then discussed in detail in the following sections. The first several sections include the findings related to each enactment process and its specific design and process conjectures. In the following sections, I present the findings related to RESET's three targeted outcomes and three general conjectures. As each teacher's case and findings were presented in detail in Chapter 4, here I only provide illustrative examples of the evidence used to determine the practicality and effectiveness of each of RESET's enactment processes and conjectures.

Figure 10

RESET PD Conjecture Map 3 - Findings



Enactment Process A: Teacher-Created Science and Engineering Curriculum

Process A: Achieved

Throughout the RESET PD, the teachers created a science and engineering curriculum (Enactment Process A). Except for the requirement that it center on the topic of solar energy engineering, the focus of the SEER program, the specifics of creating a curriculum were open-ended. This was intentional to allow teachers to create instructional plans and support materials (e.g., slide decks) tailored to their specific contexts and responsive to their students. All four of the teachers created solar energy science and engineering instructional materials and plans that they could implement in their classrooms (or others' classrooms in Abby's case) during the following school year. Additionally, all four teachers' created a curriculum that included opportunities for responsiveness to the students to some degree. For example, Tom's Carbon Footprint Reduction project included place holders for students to adapt the project according to class decisions. The project outline also included opportunities for students to learn about and share energy conservation efforts already in place on their campus, as well as ideas for future installations or projects. Thus, all four teachers *achieved* Enactment Process A, though to varying degrees (see Chapter 4).

Process Conjecture A: Partially Supported

The process conjecture related to Enactment Process A was, "If teachers design science and engineering curriculum that is responsive to their students, they will integrate CRT principles into their instructional practice in the classroom." During analysis, I found that this process conjecture was only *partially supported*. During the school year following RESET, only Abby had a chance to implement the curriculum she had planned, through working with the seventh grade students and teachers to design and build an Agri-PV, or Solar Garden, on their school campus. Abby selected the school to pitch her project idea to based on their specific context and goals, including wanting to engage students in project-based learning. She was able to ensure there was "buy in" for the project and that it would be something the school faculty and administration considered to be meaningful and empowering for the students.

Dean was able to implement parts of his curriculum, generally selecting those activities that he had seen modeled. Julie experienced contextual constraints with administrators that kept her from enacting the Agri-PV curriculum she had created.

However, she reported integrating other responsive aspects of RESET into her school year instructional practice. Ultimately, Tom did not enact his project in a responsive way, though the potential for responsiveness and the opportunity to address issues of energy equity within students' community were there. Overall, the actual *practicality* of implementing the responsive science and engineering curriculum was mixed, with two teachers implementing at least part of the curriculum they created and two teachers not using their designed curriculum either because of external factors or personal choice.

Design Conjecture A: Partially Supported

Three design features of RESET targeted supporting teachers' creation of curriculum materials: a shared Google drive with resources to support CRT and also science and engineering pedagogical strategies and the related pedagogical workshops highlighting these strategies. In the shared drive, I uploaded all of the pedagogical articles and articles related to CRT that we discussed during RESET, as well as several others we did not have time to go over. I also added a folder for each of the topics of the pedagogical workshops (e.g., productive failure, funds of knowledge), the lessons and activities the teachers observed with Jade, other lesson demonstrations by past RET or SEER staff, and Futures Thinking activities. These folders contained copies of any lesson or unit plans related to the strategy or modeled lesson, available support materials, and background information.

To illustrate, after Jade's lesson with her students about finding their purpose, I added the diagram Jade had used to the shared drive for teachers to use. The drive also contained the slide deck from Dr. Adisa's presentation, my presentation slides introducing (or reintroducing) teachers to CRT, and lessons created by the former RET participants, though teachers also received a print copy of these lessons (Ayala & Jordan, 2018). On the last day of the RET program, I projected my computer screen to remind teachers which materials were in the shared drive, make sure they knew how to access the resources, and let them know that they would have ongoing access to these resources. They all had the necessary permissions to add resources they wanted to share as well.

Knowing the time constraints that teachers often face, I felt that having these resources easily accessible to them throughout the school year would enable the teachers to continue to enact culturally responsive science and engineering teaching. Further, as the research team had discovered through previous iterations of the RET, former RET participants generally found the pedagogical workshops to be helpful in their science and engineering classroom instruction (e.g., Wakefield & Jordan, 2019). During the exit interviews, three of the teachers mentioned the shared resources or workshops as helpful. For example, Julie was excited about the possibilities of productive failure and asked for additional resources to help her implement this strategy in her classroom, which I then added to the drive. Tom noted that in past PDs, even if they were "really neat programs," he did not know "what I was supposed to do" with the learning once he returned to his classroom. With the RET generally and RESET specifically, though, "I've got a little bit more of an understanding. Plus, we have a lot of papers in the computer that I can go back to and look at and tie it all back together again." Tom explained his beliefs that having these resources to help him remember what he learned would "make a huge difference in my curriculum."

All four teachers responded to the follow up survey (see Appendix L) stating that they had implemented at least parts of the lessons or activities contained in the shared drive or discussed in the pedagogical workshops. Three of the teachers reported using the lessons created by the past RET participants. I was able to observe two of these implementations: Julie's use of a paper solar cells activity during the STEM family night and Dean's use of the solar carnival activity. Julie and Dean also reported using the purpose chart that Jade used with her students. However, none of the teachers specifically mentioned if or how they accessed these activities, or if the shared drive was helpful. Only Dean specifically mentioned a pedagogical workshop, the funds of knowledge workshop, in his follow-up survey. I included a few examples of the types of activities and resources available in the shared drives on the follow up survey, but not reminders about the pedagogical workshops. So, the teachers may not have remembered to list the strategies from the pedagogical workshops, if they had used aspects of them during the school year. However, it seems more likely that these workshops were not as impactful during this iteration as in previous iterations of the RET.

Only two of the teachers mentioned aspects of the CRT resources or principles they used in their teaching, even though I did include both the principles of CRT and reminders of the types of activities we engaged in on the survey. Abby detailed the specific activities she had facilitated related to several of the CRT principles, but did not refer to any of the articles we had read or specific resources used. Therefore, the design conjecture for Enactment Process A was only *partially supported*, both because of limited data about the usefulness of the shared pedagogical resources and workshops and only two of the teachers connecting with the culturally responsive materials. Thus, these design features were not as *practical* or useful as I had conjectured they would be.

Enactment Process B: Critically Evaluate Examples, Experiences, and Strategies

Process B: Somewhat Achieved

The second enactment process targeted by the design of RESET was the observable interaction of teachers critically evaluating the examples, experiences, and pedagogical strategies presented during RESET for issues of responsiveness and equity. Further, these discussions were designed to give the teachers opportunities "to continually and critically reflect on the ways in which their personal and professional identities inform their (in)ability to effectively meet the needs of a diverse student population" (Carter Andrews & Richmond, 2019, p. 408). Throughout the RESET PD, teachers engaged in written reflections following key events. I then facilitated discussions about these events and teachers' responses, learning, or connections to their own personal or professional lives.

Teachers also had the opportunity to engage in discussion with Jade after both observations/interactions in her classroom and once with the YS MS students.
The primary purpose of these critical discussions was to help teachers to "name and critique discriminatory ideologies and practices" and to begin to identify "pedagogical interventions that work to neutralize unequal material conditions and biased beliefs" (Bartolomé 2008, p. ix). All of the teachers engaged in both the critical written reflections and critical group discussions. However, while this enactment process was achieved in relation to the CRT examples and presentation, the discussions with the teachers following the pedagogical workshops were not as critically oriented. Therefore, Enactment Process B was only *somewhat achieved*.

While discussing CRT has (or should have) an inherent critical aspect to it, teachers are not often encouraged to critically reflect on pedagogical approaches, practices, or materials, so asking them to critique these things may actually have been more of a stretch for mid-career teachers. In the US, it is commonly assumed that the educational system and related practices and curriculum are impartial or a-cultural, so it can be challenging to recognize the inherent biases (Villegas & Lucas, 2002). Additionally, with the number of activities the teachers were engaged in during the RET and RESET, I often abbreviated these conversations in favor of allowing the teachers to work on developing their curriculum materials and because teachers were not as vocal during these discussions. This may have been because the other teacher discussions immediately followed presentations or observations. The pedagogical workshops, however, were generally linked to teachers' reading of an article or listening to a presentation on the key aspects of a specific pedagogical approach. This was not as impactful or engaging for the teachers in terms of helping them critically evaluate and implement these teaching approaches.

Process Conjecture B: Supported

The process conjecture related to Enactment Process B was "If teachers critically evaluate examples, experiences, and pedagogical strategies for responsiveness and equity, then they will develop or strengthen their role identity as a culturally responsive science and engineering teacher." This conjecture was *supported*, especially in the teachers' exit interviews at the end of the summer program. All four teachers expressed shifts in their self-perceptions, ontological and epistemological beliefs, and/or perceived action possibilities as culturally responsive teachers through their participation in the critical discussions. For example, Tom highlighted the importance of the teachers' discussion with the YS MS students in shifting his perceived action possibilities. Tom mentioned that he was "a very sarcastic person, sometimes even in the classroom" and especially after he had to tell a student multiple times to "quit doing things." However, after the discussion with the YS MS students, he realized that responding to students this way was "not the right thing to do… You've got to think from [the student's] shoes and stop sometimes."

All four teachers found their learning and identity development through the discussions following RESET events to be *practical*, in that they each expressed ways they could enact their role identities as culturally responsive science and engineering teachers with their students. How influential and lasting the development or strengthening of their role identities were varied across the four teachers. At one end of the spectrum, Tom openly acknowledged areas where he needed to improve in terms of responsiveness during his exit interview at the end of the RET program. However, Tom's observed and self-reported actions throughout the school year did not reflect long-term shifts in his role identity system in regards to CRT. Abby, on the other end of the spectrum, experienced several changes to her role identity system in terms of CRT, and she consistently implemented and highlighted these changes throughout the school year in her final interview, observation, and follow-up survey.

Design Conjecture B: Supported

Two design features of RESET were designed to foster Enactment Process B. First, the inclusion of an expert presenter - Dr. Adisa - to build teachers' knowledge of CRT and the importance of teachers examining their own perceptions and biases. The growing scholarship related to this importance has highlighted that PD plays a crucial role in teachers' ability to learn and adapt instructional tools and practices needed to address both the academic and social needs of a diverse student population (e.g., Carter Andrews and Richmond, 2019; Utt & Tochluk, 2020). The discussion amongst the teachers after Dr. Adisa's presentation was both the longest discussion, with all of the teachers contributing multiple times, and the most influential. As discussed in Chapter 4, three of the teachers had shifts in their beliefs about CRT and self-perceptions after this presentation and the teacher discussion following the presentation.

For example, Dean shared one aspect of his practice and of the contextual expectations at his school that he was questioning after the presentation:

> One of the struggles that I've had in school this year was … using questioning instead of using stern demands, telling students to do this and that. My principal was arguing that I wasn't stern enough, and because of that, kids are not learning and not paying attention. My argument was that I want to use the questioning method because I read somewhere that it's successful and make kids successful learners in the future…. And after the presentation here, I'm thinking, I guess I didn't really know my students well enough to choose either to be stern or to use the questioning method… I feel like I didn't really get to know my students, in a way…. Something is missing.

While Dean had been trying to use a method that would be responsive to his students, it was different from what the administrators felt he would be doing. After Dr. Adisa's presentation and in our teacher discussion, he now believed that "something is missing" and that his getting to know his students better could help him determine the methods that would be most successful for them. Tom agreed with Dean and the importance of "getting to know your students on a more personal basis."

Both Abby and Julie continued to refer to their learning from Dr. Adisa's talk and our teacher discussion during the school year, in their final interviews and follow-up surveys. For instance, Julie wrote on her follow-up survey that "in science we have discussed a lot more [diverse] scientists," referring to the point in Dr. Adisa's presentation when the group was able to easily identify pictures of well-known, white, male scientists and engineers (e.g., Albert Einstein), but not female scientists and engineers of color (e.g., Bessie Coleman, Mae Jemison).

In addition to Dr. Adisa's presentation and related discussion, the other design feature conjectured to foster Enactment Process B was the opportunity teachers had to discuss examples, experiences, and practices through a critical, culturally responsive lens. For instance, in several of the discussions following key RESET events, the teachers made connections between their own experiences in Solar Cell 101 and their engineering research work, where they struggled to understand the content, and their students, who may feel that way in their classrooms. The teachers had brainstormed ideas for facilitating students' understanding and being more responsive to the students who did not understand, based on what the teachers had found to be most helpful in their experiences during the RET program. The teachers appreciated being able to go back and look at their readings about solar cells again after the teachers engaged in the hands-on process of solar cell fabrication in the laboratory. The teachers also mentioned the importance of having groups with diverse expertise to support their learning and mentors who patiently re-explained or demonstrated processes when they did not understand them. Abby shared in her exit interview that these experiences had been important for the teachers to "remember what it's like to be a student hearing something for the first time…. That's a great life lesson for...veteran educators that have forgotten what it's like to be a learner in the classroom."

Design Conjecture B, "attending presentations about CRT and discussing examples, experiences, and pedagogical strategies will help teachers critically evaluate these examples, experiences, and pedagogical strategies for responsiveness and equity" was *supported*. All of the teachers participated in each discussion, and generally engaged in critical dialogue about the related RESET event. However, as mentioned previously, this happened to a lesser degree in regards to the pedagogical strategies. Additionally, one finding related to the *practicality* of the critical discussions was that it would likely have been beneficial and more responsive to the teachers if we did not always follow the same open-ended discussion format.

During one of the teacher discussions, Fernando pointed out that for the participants who came from cultural backgrounds where they waited for pauses in the conversation, or for those teachers who preferred or needed more time to process before responding, the open discussions were not ideal and tended to be dominated by a few voices. While the teachers and I then discussed how the same might be true in the classroom with their students, I need to make sure that this concern is addressed and responsiveness in the actual structure of group discussions is modeled within RESET in future iterations.

Enactment Process C: Interact with Others as Learners and Contributors

Process C: Achieved

RESET was designed to provide opportunities for teachers to interact with other teachers, the SEER staff, the YS MS students, and occasionally the YS HS students in a variety of ways. The educational system is set up and generally functions through a hierarchical, top-down structure. Program directors or facilitators who lead PD opportunities for teachers often assume a leadership role over the teachers and dictate the content and schedule of activities and how teachers are to engage with the PD. Similarly, teachers interact with students in a leadership role, where the teacher has more power than the students and students are expected to comply with the instructions of the teacher.

While the SEER program's structure and content were set up by the directors and mentors, Dr. Jordan sought to lessen this common hierarchical structure in terms of how participants were to interact and how they completed their projects during the program. Everyone participating in the SEER program in any way was positioned as both a learner and contributor (Jordan et al., in press). In other words, everyone, regardless of their role, was expected to learn from all other groups and to contribute to others' learning using their own knowledge, experience, and areas of expertise - their funds of knowledge.

In terms of RESET specifically, Dr. Jordan, Jade, and I sought to emphasize this dual role of learning and contributing when the teachers and YS MS students interacted. For example, during the teachers' "observations" of Jade and the YS MS and the initial community building activities, the teachers participated in the same activities as the students as collaborative members of the groups, rather than in a more traditional role as leaders of the activity or groups. As Tom explained regarding the teachers' time in Jade's classroom:

> I was very deliberate about not being the leader in everything I did and letting [the YS MS students] take the lead as often as possible…. And so, for me that was a different role to get to do. And it taught me a lot about what I could do in the classroom too, because I could do the same thing there.

Acting as a collaborator rather than "the leader" during classroom activities, and especially during inquiry-based activities, was "a different role" for Tom, but one he saw as being practical to implement in his classroom.

The teachers' also had the opportunity to have discussion with the YS MS students after the teachers' second interaction with the students in Jade's classroom, though for this event, the structure was similar to a focus group. The students responded to the teachers' questions about their experiences in Jade's and other teachers' classrooms. In this discussion, the students were the experts and shared their perspectives on what CRT should look like. In their exit interviews, all four teachers mentioned their appreciation for these cross-group interactions and how these activities expanded their perceived action possibilities for enacting their role identities as culturally responsive science and engineering teachers. Thus, Enactment Process C was *achieved*.

Process Conjecture C: Partially Supported

The process conjecture for Enactment Process C was that "teachers interacting with other teachers, students, and staff as learners and contributors will foster teachers' actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines." Process Conjecture C was *partially supported* because two of the four teachers demonstrated this to some extent. For example, in her exit interview, Julie talked about the work the YS MS and YS HS students were doing in conferences and within their communities. Julie explained that she loved

> seeing the youth scholars. It's really inspirational... and makes me also think about, wow, maybe I should be doing more of that with my own students… as far as collaborating and what collaborating in the world really looks like. Because in the world you're not just collaborating with your table team…. So, I'm starting to think about how I can have [my students] reach out to high school students, or … get a group of college students to come in and do an activity with them or something.

Julie learned how she could improve her own practice and perceived new action possibilities from seeing the types of work and the level of collaboration the students in the SEER programs were able to do. She wanted to reproduce those same kinds of cross-group collaborations with her students. Later, during the school year, Julie planned and implemented a school-wide STEM Family Night, to build enthusiasm for STEM within the community and to allow students to engage in STEM activities outside their classes at school and in collaboration with their families.

In part because of her specific role within her district, Abby embraced and enacted her role identity as a change agent and student advocate. Despite shifting job responsibilities, she supported the Agri-PV project at one of the district schools and sought out partnerships to support various other sustainability projects across the district to target reducing environmental inequities. In addition, Abby served as an ongoing advocate for and supporter of the YS HS students' Solar 4 Students solar pavilion project.

Her goal was to put partnerships and projects in place that could continue and spread without her direct involvement. Abby wanted to ensure the longevity of these efforts and establish a precedent for involving students in the identification, design, and implementation of meaningful science and engineering projects that supported sustainability efforts in their schools and communities.

Design Conjecture C: Supported

The design features meant to foster Enactment Process C were the inclusion of CRT examples and the participant structure of engaging teachers as learners and contributors. Interacting with Jade and the YS MS students in their classroom setting gave the teachers an opportunity to observe action possibilities for implementing culturally responsive science and engineering teaching in their classrooms, something they rarely got an opportunity to do. As Julie explained in her exit interview, "[Jade's] incredible. It's really nice to watch lessons be modeled by great teachers and not just go through it as a simulation as a teacher, but to see how the kids respond to it was really helpful." Tom agreed that teachers rarely have the opportunity of seeing other people teach. "And so, you think that what you do is the only way people do it." Therefore, Tom reported that getting the chance to observe Jade with the YS MS students was something that he could "definitely learn from."

Teachers' engagement as learners and contributors throughout RESET resulted in all of the teachers being able to interact with other teachers and the YS students in new and less hierarchical ways. Throughout the program, the teachers had the opportunity to have in depth discussions about their shared experiences in the RET, to share their past personal and professional experiences and areas of expertise, and to counter, question, or build on other teachers' ideas in a safe environment. Additionally, the teachers were able to share their ideas for the curriculum and materials they wanted to develop for their specific contexts and then receive suggestions and feedback from the other teachers, Dr. Jordan and I, Jade, and the YS MS students. Many mid-career teachers want this type of opportunity, where they have opportunities for learning, change, and growth that are specific to their interests, needs, and challenges as well as opportunities to share their professional knowledge and expertise (Day & Gu, 2007; Margolis, 2008).

The focus on teachers as both learners and contributors also fostered a collaborative and responsive environment that was different from what teachers often experienced in other PD. For example, in her exit interview, Abby explained that one of the main differences between her past PD experiences and the RET program and RESET was "the diversity of individuals I've been able to interact with." Her past PD experiences had generally exposed her to the topic "through the lens of a few individuals." Abby continued:

> This has been very, very dynamic and different. A lot of, not just one time interactions, but repeated interactions to the point where you feel like you get to know some of your collaborators throughout the experience. Everything from the middle school students, high school students, to other teachers, to graduate students, to undergraduate students, to our professors, to our education team. It's been a very, very close engagement…. I feel empowered and educated and I feel supported and I feel like this is just the beginning of a partnership and a relationship and I feel like this group has invested in me personally to prepare me and help me through whatever that end result is as an educator in my community,

in my classroom, my schools. So that's been different, and pretty cool, and pretty amazing that all of that can kind of happen in five weeks.

Abby referred to the others in the RET program - including students, other teachers, and mentors - as “collaborators,” indicating her internalization of a more equitable positioning of traditionally hierarchical relationships within education and reflecting an asset-based orientation to the students’ contributions. Abby highlighted how different it was for her to “feel like you get to know” a wide variety of collaborators and to experience “very close engagement” with these groups. The result for Abby was feeling “empowered,” “educated,” and “supported.” Terms which emphasized the importance of both her roles as a learner and a contributor.

Through Design Conjecture C, I hypothesized, “Observation of and participation in CRT examples and engagement as learners and contributors during RESET will help teachers interact with other teachers, YS students, and SEER staff in nontraditional ways, with a less hierarchical structure.” This conjecture was *supported*, and all four of the teachers considered these interactions to be *practical*. The teachers were able to see, and in several instances implement, this type of interaction in their work the following school year.

Enactment Process D: Experience a Responsive PD Environment

Process D: Somewhat Achieved

The fourth enactment process dealt with teachers experiencing a responsive PD environment to aid their own learning and growth and to model options for incorporating this type of instruction into their classrooms or other educational settings. As Abby commented in her exit interview, “I don't know if I've had such an opportunity in my past

PD to really [see a] model of ‘How do you empower students to own their learning to be a part of the process?’” Through the design of RESET, I sought to ensure that the activities’ structures had built in flexibility, the content could be adapted to be specific to the teacher’s specific students and contexts, and interactions were based in a safe, supportive community environment. In this way, I hoped to ensure that the RESET PD would be responsive to the professional and sociocultural identities of each of the teachers. However, this was only *somewhat achieved* in this iteration of RESET.

Two of the teachers, Abby and Julie, found the design of RESET to be responsive to their identities and aligned with their purposes and goals as mid-career science and engineering educators. Abby, for example, explained,

> There's been a wide variety of angles for which we've approached learning and understanding of the concepts we've been exposed to. I've never had a PD [like that. Usually it’s] very single sided: “We are going to teach you how solar panels are developed in the lab.” This is a very, very different type of experience because there's so many different objectives…. As an educator. I really appreciate that because we are all coming in at different levels and our knowledge in different areas and we have our own experiences. So, the opportunity to learn … because you're ultimately trying to help us understand how we can contribute to solar and the education of solar and the advancement of solar. But there's so many different ways that you could. You’ve exposed us to a lot, a lot to think about and a lot of information and a lot of partnerships and a lot of opportunities to continue in our learning. But to get out there and share your knowledge, join the community.

As opposed to her previous experiences with "single-sided" PD, with one specific objective and one way to accomplish that objective, Abby appreciated being able to investigate the topic of solar energy in a variety of different ways. Abby explained that she perceived new action possibilities for learning and for sharing her new knowledge and joining the solar community because of this range of opportunities. She believed that all of the teachers could find aspects of the RESET experience that aligned with teachers' "different levels," their "knowledge in different areas," and their "own experiences." In other words, that aligned with their identities as mid-career science and engineering teachers.

As the main facilitator of RESET, aspects of my professional role identities as a former mid-career K-8 educator overlapped with all four of the focal teachers. However, my identity as a white female only overlapped with two of the teachers. Therefore, it is possible that the similarities of my sociocultural identity to Abby's and Julie's resulted in these two teachers perceiving the PD as being more responsive. As discussed in Chapter 4, I was not adequately responsive to Dean's context teaching at a school in Navajo Nation and as the only elementary school teacher. Though Dr. Jordan and I both discussed Dean's curriculum development with him, Dean and I could have collaborated more extensively as I was also an elementary school teacher for many years. In his exit interview, Dean did mention that he felt he could reach out to one of the engineering mentors he had worked with if he had technical questions, as long as that was okay. I told him that it was and that particular engineering mentor had been great to work with teachers in past RETs into the school year if it was helpful for them.

Despite these in-program connection, though, Dean likely would have benefitted from opportunities to connect with other Navajo teachers, such as those who had participated in previous iterations of the RET program or those in similar school situations, where they shared the same sociocultural background with most or all of their students but experienced several external constraints in what could be implemented in their classrooms. In his exit interview, Dean shared:

> I was wondering. I noticed that most of the teachers were from [this area], except for me…. I was thinking, I wonder if there are other people that I can work with where I'm at and that have this experience also. I guess in a way I feel kind of lucky to have been here, to be the only one coming from the Navajo Nation to participate in this [RET]. That's one of the things that I appreciate, and I want to make sure to use this back on the Navajo Nation.

Dean "noticed" that he was the only out-of-area teacher and the only teacher from Navajo Nation. He wanted to establish connections with others in order to be able to implement what he had learned during the RET. Dr. Jordan was going to get in contact with past RET participants from Navajo Nation to establish connections to Dean. I also discovered late in the program that the other RET program on campus had a Navajo participant that Dean knew, so there was a missed opportunity for additional networking and support.

Process Conjecture D: Supported

The process conjecture for the responsive PD enactment process was that "if teachers experience a responsive PD environment, then they will engage in actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines." Even though all of the teachers did not achieve this outcome, the conjecture itself was *supported*, as the continuum of teachers' actions follows the continuum of the responsiveness of the PD, especially in regard to the alignment of the PD with the teachers' professional goals and purposes. In other words, Enactment Process D was achieved only when RESET was responsive to the teachers' role identities.

RESET was most responsive to Abby and Julie's role identities and both teachers were influenced to take actions as advocates and change agents during the school year. As reported in her exit and final interviews, Abby left the RET program and RESET wanting to advocate for the students and teachers in her district to be able to engage in STEM in more culturally responsive ways and she took action throughout the year to try and facilitate these changes. Julie's context and administration restricted her ability to implement her Agri-PV project with her students, but Julie was able to take action through the STEM Family Night.

For Dean and Tom, on the other hand, RESET was not as responsive to their role identities. While Dean reported enacting several aspects of CRT into his own classroom, especially aspects of giving students more choice, he did not feel comfortable or know how to advocate for changing or how to effectively navigate some of the external constraints of his school. To some extent this was culturally-related. For example, Dean mentioned in his exit interview that implementing the Futures Thinking activities "might be a challenge... As far as the culture of where I'm at, people might agree with or disagree with it." However, in other ways, Dean continued to experience challenges in finding or creating "opportunities to let students apply their funds of knowledge daily due to the expectations of completing reading, math, specials, and intervention blocks."

In Tom's case, while the solar energy content of the RET aligned well with his interests and beliefs and past actions as an educator, the focus on integrating culturally responsive science and engineering instruction for his students was not a key priority for Tom. In each of his three interviews, Tom mentioned his goal to leave the classroom and to become an administrator. Therefore, he focused his curriculum project at the district level and collaborated with university students, rather than his own students, to implement this project. This ongoing identity tension between what Tom wanted to be doing and what he was actually doing influenced his learning in and actions after RESET, as is common when these tensions exist and are not resolved (Garner & Kaplan, 2019). Thus, in order to be more responsive to Tom's role identity, I should have included more experiences, resources, or connections to the principles of CRT in relation to administration.

Design Conjecture D: Partially Supported

The design features of RESET targeting Enactment Process D, or being responsive to teachers, were teachers engagement as learners and contributors and the discussions the teachers engaged in after key events. Design Conjecture D stated that "teachers' engagement as learners and contributors and discussions of events in RESET through a critical, culturally responsive lens will help teachers to experience a responsive PD environment." This conjecture was *partially supported*. All four teachers participated in RESET as learners and contributors and participated in the critical discussions. However, this participation did not always foster a responsive environment for the teachers. Garner and Kaplan (2019) provided a possible explanation: "When role identities are in tension..., the teacher is likely to experience negative emotions, professional dilemmas, and diminished motivation" (p. 6).

For example, Tom reported in his exit interview that, through his participation in RESET, he perceived several new action possibilities for implementing some of the CRT principles in his classroom. These action possibilities were largely related to the interactions and group discussions of the teachers with Jade and the YS MS students. However, Tom continued to experience tension between his current role as a classroom teacher and his desired role as an administrator, as demonstrated in his statement during his final interview that he was "still not where I want to be." During this same interview, Tom noted several things he had been focused on throughout the school year that were "good for leadership:" attending a solar energy conference and training, putting together a team of teachers for a volleyball tournament, sharing athletic director responsibilities for his school. Throughout the interview, Tom emphasized his actions related to his targeted role identity of leader over his current role identity of science and engineering teacher. When explicitly asked about his implementation of his curriculum or any activities with his students, Tom noted,

> I am able to teach [solar energy] a lot better because of the experience I had. Again, I am not telling them that I read it in a book. I'm telling them things I've done, things I've seen, things I know, things I've experienced. I think it makes it easier to explain, to describe, to answer questions.

Tom describes his classroom instruction through a focus on his own experiences and knowledge, rather than through a responsiveness to the students.

Tom also experienced tensions between his beliefs and those presented through RESET regarding social justice and equity in education. Tom acknowledged in his final interview that “I could make some changes” in regards to fostering his identity and actions as a culturally responsive teacher, including “listening to [my] students more” and “finding their strengths.” However, Tom also reiterated his beliefs that “there are bad kids out there that are not going to change” who do not belong in a “regular classroom” but in special education or alternative schools. Tom also described his belief that not all students need to be college ready, and would prefer to see a “split track,” where by high school, “some of these kids need to be on a track for careers and some for college.” In the career tracks, students could take more “fundamental” math classes and take courses such as “woodshop and automotive and home-ec” in order to be “career ready or life ready.” Each of these beliefs countered the principles of CRT that were emphasized throughout RESET.

These tensions made it more difficult for Tom to ultimately make connections between the RESET content and his role identity as a mid-career science and engineering teacher and to be motivated to enact the perceived action possibilities he reported in his exit interview. Thus, future interactions of RESET need to have provisions for working with teachers who are experiencing these tensions in order to help them find ways forward in developing identities as culturally responsive teachers that also integrate well with their role identities as K-8 mid-career science and engineering teachers.

Enactment Process E: Empowered to Enact CRT

Process E: Achieved

The final enactment process targeted by RESET was to have teachers feel empowered to enact culturally responsive science and engineering teaching. This process was *achieved,* as all of the teachers reported specific actions during their exit interviews that they felt empowered to take the following school year. As reported throughout this chapter, these processes were achieved across a broad continuum. However, the actions teachers reported were related to at least one of the principles of CRT that we had learned about, discussed, or observed as a group. Therefore, they demonstrated that RESET had some influence on the development of their identities as culturally responsive teachers, even if this development was not extensive.

For example, Tom focused on the principle of validating students' strengths. Tom explained that he wanted to be

> more focused on watching [the students] and watching what their strengths are. Finding their strengths, and see what I can build on there…. This kid has a great imagination, so what can I do? Can I put them in some Futures Thinking, have them write me something about that and tell me what that's going to look like? Or can I have a student that's good at art, have them draw this thing out for me and show me what that's going to look like? And so, learn more about that and give kids more options in how they do things. Rather than saying, I need 28 copies of this page down here, so everybody's work should look exactly the same - because they shouldn't - [the students] should all be able to put it in their own way.

Tom did not connect this focus on students' strengths and allowing them more choice in representing their knowledge to students' intersectionalities. However, he did compare an example of his previous assignment expectations - "everybody's work should look exactly the same" - to his new goal of letting students complete assignments or demonstrate understanding in a variety of ways.

Julie also used an example related to validating students' cultures in her exit interview. Julie explained that, especially as an elementary school teacher, it was hard for her to "really talk about [social justice and equity issues]. It's not something that you really think about. You're so focused on math and reading and getting [students] to pass the tests." Now, after her participation in RESET and as she moved into her new role as a middle school teacher, she wanted to help "support [CRT] with younger grades." Julie felt that she could help her own students to become more comfortable talking about their intersectionalities, and especially their cultures, in her classroom. She then wanted to engage her students in brainstorming, "How do we help little kids talk about it?" Julie explained that she had realized that

> when you're aware and you feel comfortable to talk about [students' intersectionalities] - because I think too often we're like, "I don't know if I should say…" - but if we can get to a place where we're comfortable, and you start in some lower grades and then it filters up. Eventually it spreads.

Julie felt empowered not only to have these conversations with her own middle school students, but also to engage her students in building a school culture where talking about issues of intersectionality, social justice, and equity was "comfortable." She especially saw the potential of having more of these conversations in the lower grades at her school.

Process Conjecture E: Partially Supported

The process conjecture specific to this enactment process was "if teachers feel empowered to enact culturally responsive science and engineering teaching in the classroom, they will integrate CRT principles into their instructional practices." This conjecture was only *partially supported*. According to the teachers' self-reported actions through their final interviews and follow-up surveys during the school year, as well as my observations of their actions in various instructional settings, only three of the four teachers enacted CRT principles the following year. As I discussed the teachers' integration of CRT extensively in Chapter 4, I will not provide additional examples here. However, in a later section, I will discuss how I plan to adjust the next iteration of RESET to facilitate all participating teachers' choosing and then being able to implement in their classrooms more of the plans they felt empowered to make during RESET.

Design Conjecture E: Partially Supported

There were several RESET features designed to help teachers feel empowered to enact CRT in their classrooms. The pedagogical and CRT resources were made accessible to teachers through a shared Google drive. Additionally, each of the key events during RESET - including Dr. Adisa's talk, the interactions with Jade Whipple and the YS MS students, and the pedagogical workshops - was designed to help teachers feel empowered to enact CRT.

As reported so far in this chapter, while three of the teachers mentioned the usefulness of having the resources available, none of the teachers made consistent use of these resources either in their curriculum plans or in their instructional practice. Therefore, these materials were not influential - at least as reported in the data set - in empowering the teachers. Some of key RESET events, on the other hand, did seem to influence teachers' sense of empowerment for enacting CRT. Specifically, Dr. Adisa's talk and working with and observing Jade and the YS MS students were influential to the teachers. The pedagogical workshops were not as empowering. Again, several examples of the influences of these events have already been shared throughout Chapters 4 and 5. However, I include an additional comment from Abby's exit interview. Abby was discussing how her awareness and ideas about CRT had changed over the course of RESET, and how she wanted to "create a learning environment that's healthy for all students in the classroom." Abby continued that something that could have been improved about RESET - in regards to empowering teachers even more to take action as culturally responsive teachers, advocates, and change agents would have been to include more opportunities for "review[ing] or practic[ing] activities that are best practice to break down those barriers" in addition to "chatt[ing] about it." Abby saw the benefit of the teachers getting even more practice and review in terms of specific classroom actions teachers could take. This suggestion is also discussed further in the implications for future iterations of RESET section of this chapter.

The design conjecture connecting these design features with the targeted enactment process was, "When teachers have access to resources supporting culturally responsive science and engineering pedagogical practices, learn about CRT and observe these practices being enacted it will help them feel empowered to enact culturally responsive science and engineering teaching in their own classrooms." This conjecture was *partially supported.*

Outcomes

I addressed whether the targeted outcomes of RESET were achieved in relation to the enactment processes in the previous sections. However, as each outcome was conjectured to result from two different enactment processes, I briefly revisit the findings specifically as related to each outcome here. All three of the outcomes were *somewhat achieved*. Accordingly, RESET was *somewhat effective*, in terms of actual effectiveness (Nieveen & Fulmer, 2013), in supporting teachers to achieve the outcomes.

Outcome 1: Culturally Responsive Science and Engineering Teacher Role Identities

The first targeted outcome of the RESET PD was that the participating K-8 mid-career teachers would develop or strengthen their role identity as culturally responsive science and engineering teachers. All of the teachers made progress toward this outcome by the end of the summer, especially in terms of validating and empowering their students. The four teachers' stated role identities in their exit interviews at the end of the RESET program included a focus on increasing student voice and choice as related to their funds of knowledge and intersectionalities, something that was emphasized throughout key events and demonstrated by the YS MS. However, the results were much more uneven in terms of how teachers chose to enact the role identity they had discussed. Only three of the four teachers sustained all or part of their new or shifted beliefs, self-perceptions, and perceived action possibilities into the following school year.

I conjectured that two of the enactment processes would foster this outcome: the teachers critically evaluate key RESET events and past experiences and practices for their responsiveness and for how well they fostered equitable access to science and engineering (Enactment Process B), and teachers interactions with others in the SEER program as learners and as contributors (Enactment Process C). Both of these conjectures were supported during RESET, but, again, did not necessarily result in sustained role identities. Thus, in future versions of RESET, more support is needed to help teachers continue to develop and strengthen their role identities as culturally responsive teachers, especially when this role identity does not easily align with teachers' current ontological and epistemological beliefs and self-perceptions, as in Tom's case.

Outcome 2: Enacting Culturally Responsive Science and Engineering Teaching

The second targeted outcome was that teachers would integrate CRT principles into their science and engineering curriculum and instructional practice in their classrooms. As with the first outcome, all four teachers accomplished this outcome to at least a small degree during RESET. However, only two of the teachers were able to enact at least part of the curriculum they created with students during the school year, though there was evidence that three of the teachers integrated principles of CRT into their practice during the year following RESET. However, only one teacher appeared to make enacting culturally responsive science and engineering an integral part of their work as a mid-career educator.

The two enactment processes hypothesized to influence this outcome were the teacher-created science and engineering curriculum materials (Enactment Process A) and the teachers feeling empowered to enact CRT principles (Enactment Process E). Neither of these enactment processes resulted in all four of the teachers integrating CRT into their instructional practice the following school year. One possible factor that might have influenced this outcome, which has not been previously discussed, is while all of the teachers perceived the *practicality*, or usefulness, of implementing CRT practices by the end of RESET, the teachers also seemed to still struggle somewhat with the logistics of implementing the practices we had discussed and that they had seen Jade implement.

During both the teachers' final discussion with Jade and their discussion with the YS MS students, all of the teachers asked questions about specific procedures used to enact CRT. For example, a YS MS student explained a way that Jade maintained high expectations for the students to be accountable for and monitor their learning:

> When turning in your [assignments], you grade yourself. You would reflect on your own work. And of course, Ms. Whipple would check it. Some students can't write two sentences and then give themselves a hundred. Ms. Whipple would check and reflect on our reflections of our grading.

Tom then asked, "How did [Ms. Whipple] establish those numbers? I mean was it a rubric? How'd you know what the stuff was worth?" The student responded, "Well, there were rubrics that she made, but if you want to do extra credit, you make your own rubric and grade your own project." In this interaction, Tom was more focused on the logistics of grading and points than on the fact that Jade wanted the students to continually reflect on their own learning and that Jade felt the students were in the best position to explain their learning.

In another instance, Bianca asked the students,

> There are a lot of times where [Ms. Whipple] asked for people to share, and she doesn't tell you who needs to share. She just leaves it open ended. A lot of you take the initiative and do share. How were those expectations established?

Before the students could answer, Julie jumped in to provide additional clarification of what the teachers wanted to know: "Does she give you rules or, I don't want to say rules, but guidelines. Or some kind of a specific, ‘When I say this I expect to hear…?’ I don't know if that helps or not. Does she give you very specific guidelines on how to speak out?” One of the students explained that Jade often tells the students, “‘You have a choice to speak or not’ And then that’s when she leaves it open ended. And whoever wants to speak can speak.” The students also highlighted the culturally responsive principle of collaboration in this area. Another student in the group explained that “I basically know when somebody isn’t participating because they’re scared to do it. So, I basically just [say], ‘Hey, [student’s name], what do you think?’... because I can see that they want to say something but they’re just scared.”

As the discussion continued, Dean asked about Jade’s procedures when students do not pass a test, specifically wondering if she takes away their “recess time” or takes the time to reteach during class. The students focused on how Jade did not reteach, but they had access to all the notes in Google Classroom, and she did not take away break times, but they were welcome to choose to come in during recess or before or after school. The teachers asked similar questions to Jade the following week, and she explained many of her procedures to the teachers.

Thus, in future iterations of RESET, there needs to be more scaffolding of the pedagogical and curricula-development portion of RESET and more explicit connections between the RESET events, CRT principles, and teachers specific contexts. Not only do teachers need to hear about action possibilities for implementing CRT practices, but need to be able to find ways to apply some of these new possible actions into their specific contexts, practices, and identities. Teachers not only need to feel empowered, but also have the tools to flexibly navigate foreseen and unforeseen contextual challenges and the changing responsibilities that are often part of being a mid-career teacher (e.g., extra responsibilities, changing assignments or grade levels; van der Want et al., 2018).

Outcome 3: Actions as Change Agents and Advocates

The final targeted outcome was that teachers would engage in actions as change agents and advocates of students' equitable access to and participation in science and engineering disciplines, especially those students who have often been underserved and underrepresented in these courses, degrees and fields. The findings related to this outcome showed a difference in scale across the four teachers' actions, partly related to their specific roles and partly related to their perceived action possibilities or purposes and goals.

Abby found that being a change agent and advocate aligned well with both the responsibilities of her job and her purposes as an educator, and so her work throughout the school year reflected actions that advocated for the students and teachers in her district and sought to change some of the inequities, especially environmental inequities, experienced by the students and communities in the district. Julie was able to take some action to advocate for students' participation in STEM through organizing a school-wide STEM Family Night, though some of her other planned actions were limited by her administrators. Julie also sought to enact change in how her students' beliefs about who could be scientists and engineers. Dean made some changes in his instructional practices to allow his students more access to science and engineering activities, but had to work within the school-wide schedules and expectations. Tom planned a project to engage students in enacting change for their school campus and even district-wide, but did not end up including them in the process.

Two enactment processes were conjectured to influence this outcome: teachers' interactions with others as learners and contributors (Enactment Process C) and teachers experiencing a PD environment that was responsive to them (Enactment Process D). As discussed previously, the responsiveness of RESET to the teachers' identities did appear to follow the same continuum as the actions the teachers took the following school year. However, while all of the teachers engaged as learners and contributors, not all of them implemented actions as change agents and advocates of students' equitable access to and participation in science and engineering.

Overall Conjectures

Though this iteration of RESET did not result in all of the focal teachers achieving the three targeted outcomes, there were many promising findings. Therefore, in for the next iteration of RESET, I will keep the same high level conjecture:

> Integrating a focus on the principles of CRT as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

In terms of the overall process conjecture the missing component seems to relate to the logistics of enactment and facilitating connections between the principles of CRT and the teachers' role identities, especially focusing on teachers' purposes and goals. So, that will be addressed through the revised components of the conjecture map and in the next iteration of RESET.

The overall process conjecture for the current iteration of RESET stated:

> If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally-responsive science and engineering teaching in their classrooms.

The teachers made promising strides throughout RESET as they learned about the principles of CRT and issues of equity and social justice. However, as is often the case with PD, not all of the teachers were able to sustain their new or shifted perceived action possibilities, beliefs, self-perceptions, and expanded purposes and goals into their action the following school year (e.g., Desimone & Garet, 2015). The process conjecture will remain fundamentally the same in the second iteration of RESET, as some of the teachers were able to achieve the targeted outcomes through the enactment processes. However, I will reword aspects of the overall process conjecture to increase clarity and to align with new design features and processes that more explicitly target supporting the teachers to transfer their learning and curriculum into the school year.

The final conjecture, the overall design conjecture for the current iteration of RESET stated:

> If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and social justice issues impacting their students and increase their abilities to create,

evaluate, and enact culturally responsive science and engineering curriculum materials.

In terms of the design conjecture, the pedagogical workshop component of RESET was not as influential as planned. Therefore, I will rework this conjecture statement to emphasize the importance of making more explicit connections between the pedagogical workshops, teachers' awareness of issues of educational equity, and teachers' curriculum development for future iterations of RESET.

In the following sections, as is common in DBR studies (McKenney & Reeves, 2019), I discuss the findings of my conjecture map analysis as presented thus far in the chapter in terms of what they mean for the second iteration of the RESET PD, which I refer to as RESET 2.0. I then discuss the key implications of these findings for PD designed to support mid-career K-8 teachers' role identities and actions as culturally responsive science and engineering teachers.

Implications for the Second Iteration of RESET PD

Throughout Chapters 4 and 5, I have included brief discussion of aspects of RESET that could be improved to better foster targeted enactment processes and outcomes, either specifically for individual teachers or for the group as a whole. In this section, I focus on the key aspects of the design of RESET that need to be adapted or added RESET 2.0, based on the findings throughout these two chapters. I created a fourth conjecture map (see Appendix N) to reflect the proposed changes. Throughout these sections, I refer to the design of RESET 2.0 as proposed changes, as an important aspect of DBR is to ensure that stakeholders are involved in design decisions (Penuel et al., 2013). The content of the updated conjecture map is shared throughout this section.

Proposed Design Feature Changes

In RESET 2.0, the range of design features will remain the same. The *materials and resources* will include both pedagogical and CRT resources. The *activity and task structures* will include interactions with purposefully selected teachers, students, and guest presenters. The *participation and practices* will still include teachers' engagement as learners and contributors and their participation in critical discussions. The specific changes for RESET 2.0 are represented in Table 12 and then discussed in detail.

Table 12

Proposed Changes to the Design Features

First Iteration of RESET (1.0)	**Planned Second Iteration of RESET (2.0)**
Materials and Resources	*Materials and Resources*
1) CRT resources (articles, list of CRT attributes)	1) CRT resources: reference (articles, revised list) and interactive (enactment plan template)
2) Pedagogical resources (articles, example lesson plans and support materials)	2) Pedagogical resources: reference (articles, example lesson plans) and interactive (templates for curriculum plan)
Activity & Task Structures	*Activity & Task Structures*
3) CRT examples: Jade & YS MS	3) CRT interactions: Purposefully selected teacher(s) & students
4) CRT guest presenter: Dr. Adisa	4) CRT competence building: Expert presenter(s)
5) Pedagogical workshops	5) Pedagogical workshops w/application
Participation and Practices	*Participation and Practices*
6) Engagement as learners and contributors	6) Engagement as learners and contributors
7) Critical discussions (discuss examples, experience, practices, and content through a critical, culturally responsive lens)	7) Critical discussions (critically evaluate RESET events, science and engineering content, and teacher role identities through a culturally responsive lens)

The *CRT and pedagogical resources* will include the reference material (e.g., research articles, lesson plans) used in the RESET 1.0, as well as examples of how some of the CRT attributes or pedagogical strategies have been implemented by other teachers (e.g., one of Jade's co-created assignment rubrics). In addition, RESET 2.0 will also include "interactive" resources, or templates, that the teachers can use as a guide and adapt to fit their needs as they create curriculum plan(s) and a CRT enactment plan. In RESET 1.0, we chose to leave the specifics of teachers' school year planning open ended, in recognition of the mid-career teachers' experience and existing ways of planning. However, all of the teachers commented in their final interviews about the lack of structures and how that could be more of a challenge than a help, as it is easier to start from something than from nothing.

Thus, the purpose of the interactive materials will be to provide a starting place for teachers to record their learning, reflections, awareness of their own and students' intersectionalities and identities, purposes and goals, and plans for achieving those purposes and goals. The teachers will not be required to use these templates and will be encouraged to adapt the templates to fit their own styles and contexts (Severance et al., 2016). The teachers will, though, be expected to keep some sort of record of their experiences in RESET and how they will apply these experiences and their learning in their classrooms. The goal will be for teachers to leave RESET with clear, written plans and materials for integrating CRT principles into their work and acting as change agents and advocates of students' equitable participation in science and engineering in ways that align with their own identities as culturally responsive mid-career science and engineering teachers.

The *activities and task structure* design features for the next iteration of RESET will remain the same. However, I have renamed them to focus on the intent of the activities (e.g., competence building vs. guest presenter). I also substituted more general language, as it will not always be possible for Jade, the YS MS, and Dr. Adisa to be a key part of RESET. However, it is important in future iterations of RESET to purposefully select and include the perspectives of those actively engaged in the work of CRT, including teachers and scholars (e.g., Brown, 2017; Gay, 2018), and the voices of students (Sargeant & Gillett-Swan, 2019), as it is to them that we seek to be responsive. In addition, Jade, Dr. Adisa, and the YS MS students were purposefully selected because they represented diverse intersectionalities and sociocultural backgrounds that aligned with groups underserved and underrepresented in science and engineering.

It is not the responsibility of those from non-dominant backgrounds to teach those of us who are not (Utt & Tochluk, 2020). However, it is essential that White educators who are developing culturally responsive identities build relationships with others who can support this work and offer critical feedback. "It is particularly important that critical feedback comes from people of Color, as they are the best suited to determine what is or is not culturally relevant or who is and is not acting as an anti-racist ally" (Utt & Tochluk, 2020, p. 141). In addition to Dr. Adisa, Jade, and the YS MS students, the three participants who self-reported non-White racial or ethnic backgrounds - Bianca, Dean, and Fernando - also provided invaluable critical feedback throughout our discussions.

The *pedagogical workshops* will also be included in the next iteration of RESET. The specific approaches or strategies (e.g., productive failure - Kapur, 2016; funds of knowledge - Sias et al., 2016) highlighted in these workshops will continue to be determined by the needs of the participants and the number of workshops included by the amount of time available. Each workshop, though, will be more intentionally connected to its practical application in teachers' classrooms in ways that are responsive to their students. This will include, in addition to the critical discussions, more active modeling of the pedagogical approach (e.g., with the teachers themselves, videos of teachers enacting the approach). These pedagogical workshops will also always be connected with dedicated time for teachers to reflect on and plan for ways they could implement these approaches into their curriculum plan or into their CRT enactment plan. As demonstrated in the findings from RESET 1.0, if there is not time for both the learning and application portions of the workshop, it is unlikely that the approach will have long-term impact. Therefore, it is not effective to do only part of the workshops.

The only design feature that will remain the same in RESET 2.0, with no designed changes, is *engaging teachers as learners and contributors*. Engaging the teachers as both learners and contributors was a key aspect of RESET 1.0, as well as previous iterations of the SEER summer program (Jordan et al., In Press; Wakefield, Jordan, & DeLaRosa, 2018). This expectation for participation in the RET and RESET continues to be an important part of establishing a PD environment that disrupts traditional hierarchical relationships to model more equitable and responsive practices and to include diverse perspectives (DiGiacomo & Gutiérrez, 2017). This expectation has also been central to establishing a PD environment where critical discussions can happen. Because of the importance of the teachers engaging as learners and contributors to the enactment processes and outcomes of RESET, it is included in the conjecture map for the next iteration of RESET both as a design feature and as an enactment process.

The final design feature focuses on the expectation for teachers to engage in *critical discussions* during RESET. For RESET 2.0, this design feature was combined with the similar enactment process in RESET 1.0. Based on analysis, I realized that the discussions were more of an expectation of how to engage in the program rather than an enactment process that resulted from the RESET's design. Additionally, one of the findings about the discussions in RESET 1.0 was that the discussions needed to be adapted to include a variety of ways of discussing in order to be responsive to all of the teachers. Just using open-ended discussions focused on the reflection questions and teachers' thoughts on the events resulted in some teachers dominating the conversation. Thus, in RESET 2.0, some discussions may occur after teachers have had time to reflect and work on applying their learning to their enactment plans so that there is more time to process the event and its connections to the classroom before discussing. During the actual discussions, using different structures, such as allowing all teachers to share their thoughts and questions before opening the discussion up, or simply working with the teachers to be cognizant of different cultural styles of discussing and try applying these styles.

I also added teachers' role identities as a key part of the critical discussions for RESET 2.0 as well. According to Boveda and Weinberg (2020), educators must "examine how interconnected sociocultural identities—their own, those of students, and of other educators—influence curricular decisions and pedagogical practices, as well as power dynamics in the classroom" (p. 480). This examination, according to Utt and Tochluk (2020), is important, especially for White educators who "do not see their racial identity as meaningful [and] often allow unchecked expressions of White privilege… to create un-safe and un-welcoming classrooms for students" (p. 128). This idea was highlighted by the YS MS in their discussion with the teachers about practices that are culturally responsive. As one student described the safe and welcoming environment in Jade's classroom, it "was open to anything. You could have asked any questions. [Ms. Whipple] let you speak. She was the one that let me have my voice. Comfortably, she would just be there."

Proposed Enactment Process Changes

The proposed enactment processes for RESET 2.0 reflect the most changes from RESET 1.0. Analysis of the four teachers' cases - which illuminated the extent to which the processes, outcomes, and conjectures were achieved or supported - provided insight into the influences of the RESET's various design features. This analysis also provided insight into what needed to be changed to facilitate all participating teachers' accomplishment of the targeted outcomes. The changes are displayed in Table 13 and then discussed in detail.

Table 13

Proposed Changes in the Enactment Processes

First Iteration of RESET (1.0)	**Second Iteration of RESET (2.0)**
Participant Artifacts	*Participant Artifacts*
A) Teacher-created, responsive science and engineering curriculum	A) Teacher-created, responsive science & engineering curriculum B) CRT enactment plan
Observable Interactions	*Observable Interactions*
B) Critically evaluate key events and past experiences/practices for responsiveness	C) Explicit connections between events and targeted shifts in role identity and practice
C) Interactions with others as learners & contributors	D) Engagement as a learner and contributor

First Iteration of RESET (1.0)	Second Iteration of RESET (2.0)
Participant Experiences	*Participant Experiences*
D) Experience a responsive PD environment	E) Experience a responsive PD environment
E) Feel empowered to enact culturally responsive science and engineering teaching	F) Increased knowledge of and ability to enact equitable instructional practices in science and engineering

Enactment Process A remained the same, as *designing curriculum* is a requirement of the RET program and provides teachers with a concrete plan for implementing responsive science and engineering lesson(s) into their classrooms. In addition to designing instructional materials in RESET 2.0, the teachers will also create an *enactment plan* for implementing CRT into their instructional practice and actions as change agents and advocates (see, for example, Boveda & Weinberg, 2020; DiGiacomo & Gutiérrez, 2017; Picower, 2012a, 2012b) the following school year.

This enactment plan will be a place where teachers can record insights from their RESET experience as related to the specific attribute(s) of CRT (Brown, 2016; Gay, 2018) they want to develop or strengthen the following year. It can also serve as a place to note available resources and ideas for implementing their plans. While all of the teachers moved forward in their development of their role identities as culturally responsive science and engineering teachers during the course of RESET, the application of these ideas was not as prevalent. This was especially true in regards to specifically addressing issues of social justice and equity related to students' intersectionalities, something that is an integral part of CRT (Kelly et al., 2021) and something that is crucial in disrupting historical and systemic inequalities (Souto-Manning, 2019). Thus, in

RESET 2.0, I will make this work more explicit through the inclusion of the enactment plans.

Both of the observable interaction enactment processes targeted by RESET 1.0 will be adapted for RESET 2.0. Instead of focusing just on discussions to critically evaluate key RESET events, the new enactment process focuses on supporting teachers to make *explicit connections* between these events, targeted shifts in teachers' role identities, and specific actions teachers can implement in their classrooms or other contexts the following school year. Mid-career career teachers bring a wealth of knowledge and experience to any PD, as evidenced by each of the focal teachers (Day & Gu, 2007; van Duzor, 2011). Thus, in focusing on this group, I designed the discussions in RESET 1.0 with a low level of structure and scaffolding to help the teachers make connections between their experiences, their role identities, and the application of this learning in their classrooms. While there was evidence that all of the teachers were able to make these connections at times during the discussions, these connections did not always transfer into actions.

This is not to say that the teachers did not have sufficient knowledge or experience. It just became apparent through the findings that the teachers needed additional support in order to be able to successfully weave their new curriculum and actions into their already busy and complex responsibilities (Leitch, 2010). Further, this support needs to allow for flexible application, as mid-career teachers roles and assignments are often changing (Day & Gu, 2009), as evidenced by the fact that three of the six teachers' grade levels or content changed in the two months between their application to the SEER program and their participation. Some options for additional support could also include studying excerpts of books that address CRT from a variety of perspectives, but all grounded in the work of practicing classroom teachers (e.g., Anderson, 2020; Love, 2019; Shalaby, 2017).

The balance of offering sufficient scaffolding while still supporting teachers' agency to enact CRT as is best for their specific students can be a challenge in PD. In the most recent edition of Gay's (2018) book, *Culturally Responsive Teaching*, she specifically addressed the ongoing requests of teachers for more specific suggestions of how to implement CRT. She noted that she had included "action ideas" in this edition of the book, but explained that these ideas were "more categorical than specific" and included "some general action strategies and related resources" (p. xxxiii). These general strategies and resources would still allow teachers to use the action ideas flexibly and as appropriate for their specific contexts. As this edition of the book was not published at the time I enacted RESET 1.0, it will provide valuable information and support in RESET 2.0 to help teachers to not only feel empowered to enact CRT, but also to have additional tools to do so.

The enactment process related to teachers *engagement as learners and contributors* was primarily a wording change. In RESET 1.0, I worded this process as "interactions" rather than "engagements." I made this change for two reasons. First, as this enactment process is already part of the observable interactions section on the conjecture map, I felt that the wording was repetitive. Second, beyond just wanting the teachers to interact with others in the program in ways where the teachers are the learners at times and the contributors or experts at times, this process targets teachers truly engaging in these roles. For instance, when Tom discussed how he chose not to be the leader when he was working with the YS MS students, he was engaging in the role of a learner and collaborator with the students. This was not an explicit direction for how the teachers should interact in this activity, but rather something Tom chose to do based on seeing the benefits - for both the students and for him - of engaging in these different roles.

For the *participant experiences* section of the enactment processes, which detail how participants should experience the PD environment, the participant should feel that RESET is responsive to their professional and sociocultural identities (Edwards et al., 2019). There are no planned changes for this process from the previous iteration in terms of the conjecture map. The findings included several areas where I, as the facilitator, could have improved in how I could have made the PD more responsive to the participants' identities. That knowledge is now documented to be used in future iterations of RESET.

The final enactment process was changed from a focus on teachers feeling empowered to enact culturally responsive science and engineering teaching to teachers experiencing an *increased knowledge of and ability to enact equitable instructional practices in science and engineering.* According to Milner (2011), "Teachers from any ethnic, cultural, or racial background can be successful with any group of students when the teachers possess (or have the skills and desire to acquire) the knowledge, attitudes, disposition, and beliefs necessary to meet the needs of all their students" (p. 69-70). Teachers need to understand that equitable practices require teachers to tailor educational experiences to students' diverse intersectionalities rather than using a single approach for all students.

I changed this enactment process for two reasons. First, though all four of the teachers showed evidence of empowerment to enact at least some attributes of CRT the following school year, not all of them actually did. Thus, there was no clear connection between teachers feeling empowered to enact CRT and then actually enacting it. Also, each of the teachers connected their feelings of empowerment to specific events or interactions within RESET, often their interactions with the YS MS students. Therefore, I believe that empowerment is embedded in these events and does not need to be a specifically targeted enactment process. Instead, RESET 2.0 will focus on supporting teachers' knowledge of existing inequities in science and engineering education - including in their own beliefs, purposes, self-perceptions and actions - and increasing their ability to disrupt these practices and strengthen their identities as culturally responsive teachers.

Other Changes

The targeted outcomes for the next iteration of RESET remain the same, except that the words "in the classroom" were removed from the second outcome to reflect that the "integration of CRT principles into science and engineering instructional practice" can happen both inside and outside of the classroom. The high-level conjecture also remained the same. The wording of the overall design and process conjectures changed as reflected in Table 14.

Table 14

Proposed Changes in the Overall Conjectures

First Iteration of RESET (1.0)	Next Iteration of RESET (2.0)
Overall Design Conjecture	*Overall Design Conjecture*
If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials.	If teachers engage in critical reflection and discussion related to pedagogical workshops, interactive CRT experiences, and their role identities as mid-career science and engineering teachers, then they will increase their awareness of equity and social justice issues impacting their students and create, evaluate, and enact culturally responsive science and engineering curriculum and practices aligned with their purposes and goals.
Overall Process Conjecture	*Overall Process Conjecture*
If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally-responsive science and engineering curricula and instruction in their classrooms.	If teachers increase their awareness of equity and social justice issues impacting their students and create, evaluate, and enact culturally responsive science and engineering curriculum and practices aligned with their purposes and goals, then they will develop or strengthen their identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally responsive science and engineering curricula and instruction.

RESET 2.0 Implementation Plan

Given the proposed features, processes, outcomes, and conjectures for the second iteration of RESET, I now detail my general plan for implementing this design in RESET 2.0. I have chosen to split this design into three phases for several reasons. First, having a five-week, full time PD is rare in teacher PD. Thus, because I want RESET to be adaptable to other PD contexts, I feel splitting it into phases would allow for additional flexibility of implementation (e.g., in PD days spread across a school year). Second, the global pandemic has often forced schools to move teacher PD online. While this may or may not continue, I wanted to plan in options that are conducive to alternative modalities as well. Third, by presenting the RESET 2.0 design in phases, I hope to emphasize the importance of each of the components: laying the foundation, building and strengthening identities, and ongoing support.

Phase One: Laying the Foundation

Because RESET focuses on responsiveness to mid-career science and engineering teachers' role identities, it is important to begin with understanding teachers' identities coming into the PD. In a related research project, I have been developing and piloting an online survey instrument for science and engineering teachers which asks them to provide details about key aspects of role identities relevant to the PD, including their self-perceptions, ontological and epistemological beliefs, purposes and goals, and perceived action possibilities in these role identities. As meeting individually with teachers before or during a PD is often not feasible for PD designers and facilitators, this survey can provide them with the information they need to be responsive to the teachers.

This first phase also includes the activities that the teachers in RESET 1.0 participated in during the first two weeks of the SEER program. Teachers will complete the ICM Subset A (Boveda, 2016; see Appendix I) as a baseline for their knowledge of and beliefs about students' intersectionalities and issues of equity and social justice. The teachers will also introduce themselves and engage in "telling identities" (Sfard & Prusak, 2005) as part of getting to know all of the participants they will be interacting with, including the directors, mentors, facilitators, students, and other participants. The teachers will be introduced to CRT in science and engineering and the related CRT resources that they will use and interact with throughout the program.

Finally, in this phase, the teachers will be introduced to the expectation of engaging with others in the program as both learners and as contributors and to the expectation to critically discuss their role identities, RESET events, and science and engineering practices and content throughout the program. All of the activities that are part of Phase One can be completed online or in person. However, it is important that these activities - with the exception of the survey and ICM - are completed synchronously in order to build the community environment that fosters engagement as learners and contributors and a safe space for critical discussions.

Phase Two: Building and Strengthening Identities and Actions

During Phase Two of RESET 2.0, teachers will engage in interactions and critical discussions with the purposefully selected teachers, students, and presenters. Additionally, they will participate in pedagogical workshops focused on science and engineering pedagogical approaches that align well with CRT and will be introduced to pedagogical resources supporting these strategies. During the pedagogical workshops the teachers will examine their required content and standards and focus on ways to teach them that are responsive to students and increase students' access to science and engineering. As discussed previously in this chapter, these events are generally the same as in RESET 1.0. However, the connections between RESET events and discussions, teachers' role identities, and application of teachers' learning during the school year will be more explicit.

For example, if the teachers were again interacting with Jade and the YS MS students in RESET 2.0, they would participate in a classroom activity in collaboration with the YS MS. Then, the teachers would have opportunities to critically discuss this interaction amongst themselves, with Jade, and with the YS MS students. During and after each of these interactions and discussions, teachers will have opportunities to share their learning and ideas for application into the curriculum or the CRT enactment plan they are creating. This sharing will allow the teachers to get feedback from the group and from those with whom they are interacting. Teachers will then have allotted time to add to or revise their curriculum or plan based on their experiences, discussions, and feedback. The goal will be to continually and explicitly facilitate the teachers' achievement of the three outcomes targeted by RESET. Ideally, these events, discussions, brainstorming and feedback sessions, and creating the curriculum and enactment plans will happen in person and in blocks of time as they did in RESET 1.0. However, if this is not possible, the RESET events and workshops, with accompanying discussions and applications, could be distributed over several different PD sessions, whether in person or through virtual meetings.

Near the end of the second phase of RESET 2.0, I plan to administer the ICM Subset A again. In this iteration, however, I would like to give the teachers their responses from both time periods and have them reflect on changes (if any) in their beliefs about students' intersectionalities and share any insights they would like to share in a discussion with the group. While the ICM is helpful for me, as both the RESET researcher and facilitator, it could also be used more meaningfully as a measure of learning and opportunity for teachers to again reflect individually on beliefs that may or may not support students' intersectionalities. It also provides another opportunity for the teachers to collectively hold each other accountable for challenging "racial and cultural stereotypes, prejudices, racism, and other forms of intolerance, injustice, and oppression," a key practice in CRT (Gay, 2018, p. 37).

Phase Three: Ongoing Support

The third phase of RESET 2.0 will include a component of ongoing support. Dr. Jordan and I have both remained in contact with the participating teachers from the past several RET programs, and Dr. Jordan continues to support these teachers' work in a variety of ways. However, there is not a formal, built-in plan in the RET or RESET for regularly facilitating the continued growth of teachers' identities and actions as culturally responsive science and engineering teachers and actions as change agents and student advocates. However, continuing to support teachers over a sustained duration is an important feature of effective professional development (Darling-Hammond et al., 2017) and continuing to work as a group to strengthen each other's identities and actions as culturally responsive teachers, advocates, and change agents, can be an important way to disrupt inequitable educational practices (Utt & Tochluk, 2020).

Additionally, in order to be truly responsive to the teachers, the RESET needs to include "infrastructures to support the efforts of [teachers] so they will persevere toward high levels of [CRT] achievement… by bolstering [teacher] morale, providing resources and personal assistance, developing an ethos of achievement, and celebrating individual and collective accomplishments" (Gay, 2018, p. 39). In RESET 2.0, I plan to implement a monthly virtual support group for past RESET participants, where we can continue to engage in critical discussion and application sessions specifically focused on CRT implementation and navigating the challenges that arise throughout the school year. Additionally, I will send out a monthly email reminding teachers of their plans and available or new resources and inviting them to let me know if they need additional support. The main goal of phase three will be to support teachers' achievement of the RESET outcomes through continuing to centralize CRT as a key part of their identities and work as mid-career science and engineering teachers.

Through DBR, my goal was to study and improve the RESET PD intervention. Having described plans for the second iteration of this intervention, RESET 2.0, based on my analysis of the data from RESET 1.0, I move to a second focus of a DBR study: furthering the theoretical knowledge of the field (Cobb et. al., 2003). In the next section, I discuss the general implications of the findings from the first iteration of RESET.

Implications for Scholarship

Through this study, I sought to contribute to the scholarship on how to support mid-career K-8 teachers in (a) becoming more culturally responsive to their students' intersectionalities and (b) advocating for and becoming change agents for students' increased participation and success in science and engineering courses and disciplines. From my analysis of the four teachers' cases and the RESET conjecture maps, I propose three key implications for future work in this area. First, fostering teachers' identities as culturally responsive teachers, change agents who disrupt inequitable educational practices, and advocates of their students' rightful presence in science and engineering (Calabrese Barton & Tan, 2019) should become a central goal of science and engineering PD. Second, teacher PD should be designed to reduce rather than reproduce hierarchical power relationships through including and even highlighting the perspectives of those who have largely been made invisible in teacher PD (e.g., students, educators of color). Third, designing, implementing, and studying teacher PD should be grounded in frameworks developed by scholars from a variety of disciplines and designed to consider the complexity of teaching and learning.

Centralizing Teachers' CRT Role Identities

Teachers' identities and a focus on issues of social justice and equity in education have been largely absent from the literature on PD for inservice teachers until recently (Carter Andrews & Richmond, 2019). The oft-cited studies that provide a list of characteristics of "effective" PD (e.g., Darling-Hammond et al., 2017; Desimone, 2011) have not included a focus on equity or identity. Yet, though generally unintentional, many teachers "are in denial about how their practices are sometimes inadequate to meet the needs of their students, especially their culturally diverse students" (Milner, 2011, p. 57). This is because initial (and continuing) teacher education generally determines "quality" by how aligned a practice is with dominant Eurocentric ways of knowing, which centers Whiteness and fosters the continual reproduction of inequality and racism (Matias, 2013; Souto-Manning, 2019).

Thus, according to Carter Andrews and Richmond (2019), PD that supports teachers in learning and implementing CRT - or similar resource pedagogies - practices is crucial. These authors encouraged researchers to expand their view of what makes PD effective, or even powerful, and argued that PD designers and facilitators should ensure that teachers participating in the PD "develop the self-efficacy to embody and demonstrate pedagogies and practices that are informed by social/cultural context and professional identities oriented toward all students having access to the learning opportunities they need to maximize academic and life success” (p. 409). RESET was designed to target these outcomes through centralizing CRT “pedagogies and practices” related specifically to science and engineering instruction and seeking to foster teachers’ identities as culturally responsive science and engineering teachers, advocates, and change agents.

While the findings of this study varied across the four teachers, the teacher who was able to achieve all of the targeted outcomes of RESET 1.0 was also the teacher who was able to embrace the process of reflecting on, critiquing, and changing aspects of her role identity as a culturally responsive science and engineering educator. Though I do not present this as a causal relationship, evidence confirmed that participation in RESET did influence Abby’s role identity beliefs and self-perceptions as well as her perceived action possibilities and eventual actions as a change agent and advocate for underserved students’ access to and rightful presence in science and engineering disciplines. As Abby learned more about what CRT actually entailed and had the opportunity to discuss with others how her past actions - which she saw as being culturally responsive at the time - were actually detrimental to some groups of students, she was “empowered” to make changes the following school year.

As Matias (2013) explained, “if White teachers want to support the healthy development of racial identity among students of Color, they must acknowledge the implications of the overwhelming presence of whiteness indicative of the majority of urban school teachers” (p. 68). In other words, they need to do the work to interrogate and understand their own racial identity as a White teacher (see also Utt & Tochluk, 2020). White teachers especially need to engage in this identity work, as it is White privileges that allow them to “not be necessarily concerned about the role of race in society and their work” in the first place (Milner, 2011, p. 59). However, Gay also (2010) noted that, while teachers who share similar ethnicities with their students can be beneficial for the students, it is not a “guarantee” of effective teaching (p. 205).

Each of the focal mid-career teachers in RESET 1.0 had previously attended PD focused specifically on CRT or similar approaches to multicultural education. Yet, in their exit interviews, all four teachers mentioned practices they needed to change to become more responsive to their students and aspects of being responsive that they had not previously thought about. This finding highlights that addressing educational inequities and issues of social justice through a one-time training removed from the content and contexts of teachers’ work is not sufficient to produce shifts in teachers’ role identities, nor to make becoming culturally responsive a key part of mid-career teachers’ role identities. A focus on the attributes of CRT (or other similar approaches) should be incorporated into all teacher training in a way that connects teachers’ own professional purposes and goals with responsive teaching and the responsibility to actively counter inequitable and unjust practices and create equitable environments for students.

Just as teachers should be expected to be responsive to their students’ diverse intersectionalities, it is critical that continuing work in designing PD that centralizes teacher identity and issues of equity is responsive to teachers’ diverse intersectionalities and professional identities. PD will not truly be effective until it results in teachers who are actively working to ensure an equitable education and academic and social success for all of their students.

Highlighting Diverse Voices and Perspectives

In addition to making educational equity and identity integral, PD providers also need to focus on whose voices "count," in science and engineering (Wilson-Lopez et al., 2017). Just as there needs to be greater diversity in the teaching profession, there needs to be greater diversity in who is being positioned as an "expert" in PD. As Utt & Tochluk (2020) asserted, "No matter how much White teachers do internal work and engage with other White people, ensuring that this internal growth transforms into a solid culturally responsive and/or anti-racist praxis requires building relationships across race" (p. 144). Additionally, interactions and relationships within PD should extend beyond just racial or cultural diversity to "simultaneously include a commitment to anti-oppressive identity development with feminist analysis, class-consciousness, anti-heterosexist practice, and more" (p. 139).

One way to build these connections and relationships is to not only include, but also highlight the voices and perspectives of those who have traditionally been excluded from being contributors to teachers' learning (DiGiacomo & Gutiérrez, 2017). This includes other teachers, students, and scholars, especially those from a variety of sociocultural backgrounds and with insight into ongoing issues in education related to differences in students' gender, socioeconomic backgrounds, academic and other abilities, and so on. From the findings of this study, it was clear that the teachers found their interactions with Dr. Adisa, Jade, and the YS MS students to be influential to their CRT identities, and for most of them, influential to CRT actions the following school year. Further, by positioning everyone who participated in the SEER program as both a learner and contributor, it opened the possibility for more interactions where the teachers were learning from those not in traditional, designated “leadership” roles. Especially in terms of their interactions with the students, the teachers all mentioned in discussions and exit interviews how these interactions had allowed them to perceive new action possibilities for their own instructional practice and for becoming more responsive to students. The teachers especially resonated with the CRT practice of encouraging and enabling students to find and use their own voices and to actively participate in their own learning (Gay, 2018).

Despite these findings and the importance of student voice in CRT, “authentic youth–adult partnerships” related to transforming schools are generally “uncharted territory” (Beattie, 2012, p. 160). Children’s views continue to be ignored in educational reform (Sargeant & Gillett-Swan, 2019), especially when “systemic improvement is prioritised over student agency and the right of young people to democratic participation in their schooling” (Charteris & Smardon, 2019, p. 305). This is unfortunate, because in this study, the YS MS students provided important perspectives and insights into if and how instructional practices used by the teachers fostered their access to and perseverance in science and engineering.

As demonstrated by Jade, students can be taught how to engage with teachers and other community members and can develop confidence in doing so. Additionally, Sargeant and Gillett-Swan (2019) provide guidance for educators to seek and implement students’ perspectives and DiGiacomo and Gutiérrez (2017) provide an example of “a social design experiment... organized around dynamic notions of culture, an equity-oriented approach to design and democratizing forms of inquiry in which mutual relations of exchange between youth, adults, communities, and researchers are advanced” (p. 43).

All of this work, along with the findings from this and future iterations of RESET, could provide a foundation for future research into including a more diverse group, consisting of students, teachers, and others with various sociocultural backgrounds, funds of knowledge, and expertise to engage as learners and contributors to science and engineering teacher PD.

Diversifying the Use of Frameworks

The first two key implications of this study for general knowledge and theory advancement have focused on specific design aspects of PD. The third implication relates to the full DBR process of designing, implementing, and studying teacher PD for science and engineering teachers. I argue that DBR studies of PD should be grounded in frameworks using multiple lenses and frameworks that embrace, rather than overly simplify, the complexities of the focal topics of study: teacher identity and CRT. Through this study, I found that using a combination of theoretical and methodological frameworks of this type could be used synergistically to good effect.

I selected DSMRI (Kaplan & Garner, 2017) as my primary theoretical framework related to teacher identity. This framework was created by educational psychologists and focuses on identity as a complex, interactional system that can provide insight into teachers' learning in PD and related instructional actions (Garner & Kaplan, 2019). I found this framework to be especially useful in my work with mid-career teachers, who generally have strong beliefs, self-perceptions, purposes and goals, and perceived action possibilities related to their roles as mid-career science and engineering teachers, and even, at times, as related to their role identity as culturally responsive teachers. DSMRI provided a way for me to examine these aspects of teachers' identities not only as they impacted each other, but also as they related to different roles mid-career teachers are often asked or choose to take on. Further, the DSMRI also recognizes the ongoing influence of factors such as the domain or context in which teachers work, as well as their emotions as related to teachers' actions.

CRT, as conceptualized by Gay (2000, 2010, 2013, 2018) and others (e.g., Aronson & Laughter, 2016), has been discussed in the literature mostly through the lenses of teacher education and critical theories. RESET 1.0 was specifically designed to be a part of the SEER RET program, which focuses on supporting teachers in transferring their own experiences in the program into their instructional practice in order to increase underserved students' access to and participation in science and engineering disciplines. Thus, CRT provided an important framework for guiding the design of a PD intervention that provided opportunities for teachers to critically examine their own sociocultural and professional identities and actions as science and engineering teachers. CRT also provided a framework designed to be used in teacher education settings to support teachers in becoming responsive to their students' intersectionalities.

Finally, I found Boelen et al.'s (2020) analysis process - as expanded from Sandoval's (2014) work on conjecture mapping - to be a useful DBR analytical framework. Using this process, I engaged in an analysis process to determine whether the enactment processes and outcomes of RESET 1.0 were achieved or not, and whether the design and process conjectures were supported or not. Through initially creating and then analyzing evidence related to these specific conjectures, in addition to the high-level conjectures included by Sandoval (2014), I was able to more closely determine the strengths and weaknesses in the design of RESET, as well as explain to readers how I evaluated each conjecture and the findings that supported or did not support my findings. Additionally, I was able to make detailed changes to the proposed design of RESET 2.0 based on my findings from analysis of the specific process and design conjectures.

DBR researchers have generally relied on extensive narrative accounts of each aspect of their work: design, implementation, adaptations, iterations, analysis, and outcomes (Bakker, 2018). This reliance on narrative accounts is something that has been criticized as a weakness of DBR (Coburn, 2003; Sandoval & Bell, 2004; Shavelson et al., 2003). These researchers questioned whether the narrative accounts adequately addressed alternative explanations as well as the replicability and generalizability of results. Thus, I found that Boelen et al.'s process of conjecture map analysis increased the methodological and analytical rigor of my study and findings, by adding an additional layer of analysis to my narrative accounts, and evaluating the extent to which my outcomes were achieved.

Taken together, these three frameworks allowed me to explore how a designed PD intervention could support teachers' role identities and actions as culturally responsive teachers, change agents, and student advocates. The next, and final, section provides a summary of and conclusion to this dissertation study.

Conclusion

Both elementary and middle school teachers play an important role in how their students perceive science and engineering and further, how they perceive who can be a scientist or engineer (Riegle-Crumb et al., 2010). As mid-career teachers often serve as mentors of new teachers, shaping many of the new teachers' instructional practices, it is important that mid-career teachers develop and enact role identities as culturally responsive science and engineering teachers (Margolis, 2008; Segura et al., 2019). This goal should be focal to all PD (Carter Andrews and Richmond, 2019), but especially to science and engineering PD, as many groups of students continue to be underserved and underrepresented in these courses and careers.

As detailed in chapter 3, this study focused on a PD intervention - RESET 1.0 - designed to support mid-career K-8 teachers in this work. Specifically, Gay (2018) explained that, in order to realize the potential if CRT, it would require teachers who have

> (1) thorough knowledge about the cultural values, learning styles, historical legacies, contributions, and achievements of different ethnic groups; (2) the courage to stop blaming the victims of school failure and to admit that something is seriously wrong with existing educational systems; (3) the will to confront prevailing educational canons and convictions, and to rethink traditional assumptions of cultural universality and/or neutrality in teaching and learning; (4) the skills to act productively in translating knowledge and sensitivity about cultural diversity into pedagogical practices; and (5) the tenacity to relentlessly pursue comprehensive and high-level performance for children who currently are underachieving in schools. (p. 53)

The outcomes of RESET 1.0, which targeted the development of these characteristics in participating teachers, were only partially achieved across the four focal participants (see Chapter 4). However, the findings of this study provided important insights for RESET 2.0 and for the scholarship on identity and CRT-focused science and engineering PD, as detailed throughout this chapter.

I conclude my dissertation with the hopeful challenge of DiGiacomo and Gutiérrez (2017):

> Teaching and learning are iterative, recursive, and situated processes with ongoing and persistent moments of great challenge, alongside rich moments of insight, reflection, revision, and re-imagination. Working to change such processes takes time, support, and opportunities to repair one’s own thinking and practices. (p. 46)

In designing, implementing, and examining RESET 1.0, I experienced many “moments of great challenge,” but also appreciated the opportunities for moments of “reflection, revision, and re-imagination.” At the end of the RESET 1.0 journey and beginning of the RESET 2.0 journey, I look forward to continuing the work to “repair” my thinking and practices and to support other teachers as they do the same.

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APPENDIX A

RESET CONJECTURE MAP 1: MAY

High-Level Conjecture: Integrating a focus on the principles of culturally responsive teaching as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

Design Features	DC →	Enactment Processes	PC →	Outcomes
Materials & Resources		**Participant Artifacts**		**O1**
1) CRT resources	A, F	A) Teacher-created, responsive science & engineering curriculum	O2	Development or strengthening of role identity as a responsive science & engineering teacher
2) Pedagogical resources	A, F			
Activity & Task Structures		**Observable Interactions**		**O2**
3) Learner & Contributor Community Building	D, E	B) Critically evaluate key events and experiences/ practices for responsiveness	O1	Integration of CRT principles into science and engineering instructional practice in the classroom
4) CRT examples: Jade & YS MS students	D, F			
5) CRT Guest Presenter: Dr. Adisa	B, F	C) Curriculum consultations	O1	
6) Pedagogical workshops	A, F		O3	
7) Science/Engineering Experiences	A, B	D) Interactions with others as learners/ contributors		
Participation & Practices		**Participant Experiences**		**O3**
8) Engagement as learners and contributors	D, E	E) Experience a responsive PD environment	O3	Actions as change agents & advocates of students' equitable access to and participation in science and engineering disciplines
9) Discuss examples, experiences, practices, and content through a critical, CRT lens	B, E	F) Feel empowered to enact CRT in science & engineering	O2	

Design Conjecture (DC): If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials.

Process Conjecture (PC): I If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally-responsive science and engineering curricula and instruction in their classrooms.

APPENDIX B

LETTER OF IRB APPROVAL

APPROVAL: MODIFICATION

Michelle Jordan
Division of Teacher Preparation - Tempe
[Blinded]

Dear Michelle Jordan:

On 5/30/2019 the ASU IRB reviewed the following protocol:

Type of Review:	Modification
Title:	[SEER] Summer Program: Evaluating a program with a diverse cohort of participants
Investigator:	Michelle Jordan
IRB ID:	STUDY00006290
Funding:	Name: IAFSE-ECEE: [SEER] ERC Consortium
Grant Title:	None
Grant ID:	None
Documents Reviewed:	• IRB [SEER] summer consent _public communication writing project.pdf, Category: Consent Form; • IRB Application_[SEER]__REU_RET_YS_Mentor_Revised May 2019.docx, Category: IRB Protocol; • mentor pre survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • Spanish Parent Consent , Category: Consent Form; • RET pre survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • adult consent, Category: Consent Form; • Spanish parent recruitment email , Category: Recruitment Materials; • Post Public Communication Writing Project_New_Interview Protocol.pdf, Category:

	Measures (Survey questions/Interview questions /interview guides/focus group questions); • parent consent, Category: Consent Form; • YS pre survey , Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • mentor post survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • REU pre survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • example written assignments, Category: Participant materials (specific directions for them); • Solar 101 survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • recruitment email for parents, Category: Recruitment Materials; • semi structured interview questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • RET post survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • REU post survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • HRP-502c - Public CONSENT DOCUMENT - SHORT FORM.pdf, Category: Consent Form; • YS post survey, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • RET Follow Up Observation Consent, Category: Consent Form; • Certificate of Accurate Spanish Translation, Category: Translations; • youth assent, Category: Consent Form; • [SEER] Full Proposal from Fastlane (2).pdf, Category: Sponsor Attachment;

The IRB approved the modification.

When consent is appropriate, you must use final, watermarked versions available under the “Documents” tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:
Wendy Wakefield

APPENDIX C

SEER PROGRAM CONSENT FORM

Dear Potential Participant,

Dr. Michelle Jordan from the [BLINDED] Teachers College at [BLINDED] University, and her research team, are conducting a research study to assess the effectiveness of the [SEER] summer research experience for all participants, including undergraduates (i.e., REUs), teachers (i.e., RETs), high school students (YS), as well as their QESST graduate student/post-doc mentors.

As part of the study, we are recruiting individuals to participate in four ways:

- Answer a series of survey questions related to the summer research experience. Surveys will be given four times, once at the beginning of the [SEER] research experience program, once at the end of Solar 101, at the end of the summer program, and one follow-up survey during the year following your summer participation. Each survey will take approximately 20-30 minutes to fill out.
- Participate in three interviews with a member of the research team, one at the beginning of the summer program, one at the end of the summer program, and a follow-up interview later in the year. The interviews will be conducted at a time and place that is convenient for you. Each interview will take approximately 30 minutes. We would like to audio record the interviews. Interviews will not be recorded without your permission. Please let the researcher know if you do not want the interview to be recorded. You also can change your mind after the interview starts; just let the researcher know if you want to stop the interview at any time.
- Allow the research team to use your written assignments from the program as data for the study. This aspect of the study will not take up any of your time.
- Allow the research team to observe and audio-video record your participation in program activities, including all [SEER] activities that occur during the summer program and any follow up activities that take place during the subsequent year. Only the research team will have access to the recordings for study purposes. This aspect of the study will not take up any of your time. Only recorded data from participants who have provided consent will used in the research.

Your participation in this study is voluntary. If you choose not to participate or to withdraw from the study at any time, there will be no penalty (e.g., it will not affect your participation in the [SEER] summer program). You must be 18 or older to give your consent to participate in the study. If you are under 18, a parent or legal guardian must give consent for you to participate.

Although there will be no immediate benefit to you, the information gained from this study will contribute to improving current methods of instruction in engineering research centers and related programs. There are no foreseeable risks or discomforts to your participation.

Confidentiality will be maintained by the removal of all identifying information from written assignments prior to any analysis of the data. We will ask you to provide a unique study id for each survey so that we can track you without associating the data with your name. This id will be the first three letters of your mother's name and the last three numbers of your phone number. The study id will enable us to link participants across different types of data. All data will replace participant information with each participant's study id tracked via a masterlist. The masterlist will be stored separately from the data in a locked file cabinet together with consent forms. All electronic data will be stored in a password-protected computer and erased at the end of the study. Transcripts will be made of audio-video and audio recordings, and all names will be replaced with pseudonyms. Only participation of participants who have given permission to have their recorded data used in the study will be transcribed. Study results may be used in reports, presentations, or publications but your name will not be known or used because identification will have been removed.

If you have any questions concerning the research study, please contact Michelle Jordan at [BLINDED]. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the chair of the Human Subjects Institutional Review Board through the [BLINDED] office of Research Integrity and Assurance.

Thank you for your consideration,
Dr. Michelle Jordan, Principal Investigator and [SEER] Education Director
----

By checking the appropriate boxes and signing below, you acknowledge that you understand the information provided to you, your participation in the study, and the components of the study.

____Yes, I will participate in the study.

> ____ Yes, I will complete the surveys. The researchers have my permission to use my survey data in the study.
>
> _____ Yes, the researchers have my permission to retain and analyze my written assignments and reflections related to the summer research program.
>
> ____ Yes, the researchers have my permission to audio-video record my participation in the [SEER] research experience program and to use those recordings as data for the study.
>
> _____ Yes, I will participate in the interviews. The researchers have permission to audio record, transcribe, and analyze my interviews for the study.

_____ I am 18 years or older.

____ _____________________

Signature Date

PRINTED NAME: ____

I am participating in the summer research program in the following capacity:

___ Mentor ____ REU ____ RET _____ YS

Please provide your study ID. The ID is: the first three letters of your mother's name and the last three numbers of your telephone: _________________________

APPENDIX D

RESET CONJECTURE MAP 2: JUNE

High-Level Conjecture: Integrating a focus on the principles of culturally responsive teaching as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

Design Features	DC →	Enactment Processes	PC →	Outcomes
Materials & Resources		**Participant Artifacts**		**O1**
1) CRT resources	A, E	A) Teacher-created, responsive science & engineering curriculum	O2	Development or strengthening of role identity as a responsive science & engineering teacher
2) Pedagogical resources	A, E			
Activity & Task Structures		**Observable Interactions**		**O2**
3) CRT Examples: Jade & YS MS	D, E	B) Critically evaluate key events and past experiences/practices for responsiveness/ equity	O1	Integration of CRT principles into science and engineering instructional practice in the classroom
4) CRT Guest Presenter: Dr. Adisa	B, E	C) Interactions with others as learners/ contributors	O1, O3	
5) Pedagogical workshops	A, E			
Participation & Practices		**Participant Experiences**		**O3**
6) Engagement as learners and contributors	C, D	D) Experience a responsive PD environment	O3	Actions as change agents & advocates of students' equitable access to and participation in science and engineering disciplines
7) Discuss examples, experiences, practices and content through a critical, culturally responsive lens	B, D	E) Feel empowered to enact culturally responsive science and engineering teaching	O2	

Design Conjecture (DC): If teachers participate in pedagogical workshops and engage in critical reflection and discussion related to science and engineering instruction (examples, experiences, and strategies), then they will become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials.

Process Conjecture (PC): If teachers become more conscious of equity and social justice issues impacting their students and increase their abilities to create, evaluate, and enact culturally responsive science and engineering curriculum materials, then they will develop identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally-responsive science and engineering curricula and instruction in their classrooms.

APPENDIX E

STUDENT FUNDS OF KNOWLEDGE INVENTORY

(from Sias, Wilson-Lopez, and Mejia, 2016, p. 33)

Engineers make a world of difference, improving the quality of everyday life for people in our families, our communities, and our world. What problems have you seen in your everyday life that could be solved through engineering? Have you developed solutions to these problems? The purpose of this inventory is to begin to identify experiences and skills you already have that relate to engineering.

Household and Community

(1) What problems have you seen in your homes or communities that could be solved through engineering? What ideas do you have for solving these problems?

(2) Have you ever built, fixed, improved, or remodeled something in your house, yard, or neighborhood? If so, please briefly describe what you did.

Workplace

(3) Do you hold a job, or have you ever helped your family members with their jobs? Please describe a typical day in the workplace for you or for a family member.

(4) What problems have you or your family members solved as part of your jobs?

Recreation

(5) What do you like to do in your spare time outside of school?

(6) What problems do you face when you are doing these things in your spare time?

(7) Do you play any apps or video games that are related to engineering? If so, please describe how you play this game.

International Experience

(8) What problems have you seen or read about in another country that could be solved through engineering?

APPENDIX F

REFLECTION AND DISCUSSION QUESTIONS

Throughout the RESET program, teachers will engage in reflection and discussion about the key examples, workshops, and experiences in which they participate. The following questions were adapted from Janks (2000) four major themes of critical literacy and Wilson-Lopez et al.'s (2017) adaptation of these themes for engineering. These questions served as a starting point to guide teachers' reflections and discussions.

Think about the following questions in relation to the focal example, experience, or pedagogical workshop:

- Who "counts" as an engineer?
- Whose knowledge and ways of knowing and doing "count"?
- Who gets to define and address problems that can be solved through engineering?
- Who benefits? Who pays?
- How does diversity, or lack thereof, contribute to specific outcomes at different stages of the engineering design process?
- What concerns do you have about this example, experience, strategy, or standard(s)?
- How could a counter-design address those concerns?
- How does it provide access to accepted engineering practices for underrepresented populations?
- How does it challenge accepted engineering practices to move toward social justice and equity?

Considering this example, experience, or workshop:

- What is important to implement in my class/school/community?
- What do I feel is possible to implement in my class/school/community?
- What could get in the way of implementing this in my class/school/community?
- What assets can I draw on (both assets that students bring and external assets)?
- How else might this work? How else could this be designed?

APPENDIX G

SEMI-STRUCTURED INTERVIEW PROTOCOL: INITIAL INTERVIEW

Thank you for allowing me to talk with you today. I am part of the research team that is evaluating the summer research program, and we are interested in your experiences both as an educator and as a participant in the RET program. The information you provide will be used to make modifications and improvements to the program and also to prepare reports to the National Science Foundation (NSF) on the extent to which the program has met its goals and objectives. It may also be used in research presentations and articles, but neither your name nor any other identifying information will be used. I anticipate that this interview will last about 30-40 minutes.

Your participation in this interview is voluntary, and you may choose not to answer a question or to quit at any time. I would like to audio record this interview, but it will not be recorded without your permission. You can change your mind after the interview starts; just let me know. I anticipate that this interview will last about 30-40 minutes.

Before we begin, do you have any questions?

Do you provide your consent for me to begin recording this interview?

{IF YES, START AUDIO RECORDING}

What is your STUDY ID?

Mid-Career STEM/Engineering Teacher Identity (adapted from Garner & Kaplan, 2019)

1. Please tell me about yourself as a teacher.
    a. What brought you to the field of education? What has kept you teaching?
    b. How would you (or others) describe yourself as a teacher?
2. What do you see as the purpose(s) of teaching?
3. How/why did you become a STEM subject area teacher?
    a. If they are a generalist (usually elementary): What STEM subjects are you responsible to teach to your students?
4. What are the most meaningful experiences you have had as a teacher generally? As a STEM subject area teacher? Why were they so meaningful?
5. What are your main concerns and challenges as a teacher generally? As a STEM subject area teacher specifically?
6. Do you consider yourself to be an engineering teacher? Why or why not?
7. What do you see as the benefits of engaging your students in engineering?
8. What do you see as the potential challenges to teaching engineering?
9. How do you imagine yourself in the future? What goals do you have for yourself professionally?
10. What are you most uncertain about in relation to engineering teaching and learning yourself as an engineering teacher?

Social Justice Advocate Identity (adapted from Altman, 2017; Nyachae, 2018)

I'd like to ask you a few questions about the ways in which you see social justice issues in your own classroom. You may not use the phrase *social justice*. You or others may refer to some of the same ideas as *equity, equality, justice* or *fairness* in society.

1. What is your current understanding of social justice (and/or social justice teaching)?
2. What social justice issues do you think are most relevant to your own students and your own classroom? Are there issues you see as being particularly not relevant? [If necessary, prompt teacher by noting that these issues can either be external issues that are visible in the classroom or class-based concerns that relate to social justice issues]
3. Have you taken any steps to address any of the issues you just named with your students? These steps might have been taken through planning, through your choices about teaching practice, through discussions with students, or in any other way.
4. What issues do you feel most able to address or otherwise impact? What issues do you feel least able to address or otherwise impact?
5. If any, what difficulties have arisen in your practice around issues of social justice? For example, an issue that you see as relating to social justice might have proven particularly difficult to address, or it might have negatively impacted learning for a particular student or group of students.
6. What do you think are the most important ways to support teachers' work to broaden underrepresented students' access to and participation in STEM?

APPENDIX H

SEMI-STRUCTURED INTERVIEW PROTOCOL: EXIT INTERVIEW

Thank you for allowing me to talk with you today. I am part of the research team that is evaluating the summer research program, and we are interested in your experiences both as an educator and as a participant in the RET program. The information you provide will be used to make modifications and improvements to the program and also to prepare reports to the National Science Foundation (NSF) on the extent to which the program has met its goals and objectives. It may also be used in research presentations and articles, but neither your name nor any other identifying information will be used. I anticipate that this interview will last about 30-40 minutes.

Your participation in this interview is voluntary, and you may choose not to answer a question or to quit at any time. I would like to audio record this interview, but it will not be recorded without your permission. You can change your mind after the interview starts; just let me know. I anticipate that this interview will last about 30-40 minutes.

Before we begin, do you have any questions?

Do you provide your consent for me to begin recording this interview?

{IF YES, START AUDIO RECORDING}

What is your STUDY ID?

RET Experience and Impacts

1. How has the RET program been similar to your past PD experiences? How has it been different?
2. What are your main “take-aways” from the program?
3. Which activities or experiences during the program were most useful to you as a STEM teacher or educator? Least useful?
4. When did you experience uncertainty during the program and how did you manage that uncertainty?
5. What do you think about the experience of participating with a diverse cohort including middle and high school students, undergraduates, other teachers, and mentors?
6. How did the activities you participated in as a RET in the SEER program influence your development of your lesson plan?
   a. What would you like your engineering/STEM instruction or implementation to “look like” this coming school year?
   b. What do you plan to do differently than before your participation?
   c. What kinds of support do you anticipating wanting or needing?
7. Have any of your future professional goals, plans, or how you see yourself as a teacher changed as a result of participating in the RET? If so, how?

Culturally Responsive Teaching and Social Justice

8. Have your views on social justice and culturally responsive teaching changed as a result of participating in the RET? If so, how?
9. What RET activities were most meaningful to you in learning to engage in responsive teaching?
10. What social justice issues do you think are most relevant to your own students and your own classroom? [either external issues that are visible in the classroom or class-based concerns that relate to social justice issues] Are there issues you see as being particularly not relevant?
11. What issues of social justice and making your instruction culturally responsive do you feel most able to address or otherwise impact? What issues do you feel least able to address or otherwise impact?
12. What do you think are the most important ways to support teachers' work to broaden underrepresented students' access to and participation in STEM?
13. Do you have any other feedback for us to help us improve the program?

APPENDIX I

INTERSECTIONAL COMPETENCE MEASURE - SUBSET A

(from Boveda 2016)

This measure consists of 18 multiple choice questions. For each question, please select the response that best reflects your experience as an educator. Each question is followed by a sub-question where you can provide any additional comments or explanation about the question or your response, if you would like, but this is not required.

What is your Study ID? ________________________

1) Is student achievement related to the teachers' academic expectations?
   Not at all related
   Slightly related
   Fairly related
   Quite related
   Extremely related

1a) Any comments related to question 1 or your response?

2) Are people with disabilities adequately represented in K-12 textbooks today?
   Not represented at all
   Slightly represented
   Fairly represented
   Quite represented
   Extremely represented

2a) Any comments related to question 2 or your response?

3) Is the attention that girls receive from teachers in schools comparable to the attention boys receive?
   girls receive much more negative attention than boys
   girls receive slightly more negative attention than boys
   girls receive the same attention as boys
   girls receive slightly more positive attention than boys
   girls receive much more positive attention than boys

3a) Any comments related to question 3 or your response?

4) In the United States, is privilege—or unfair advantages and access to opportunities—associated with the combination of masculinity, White skin, and wealth?
   not at all associated with that combination
   slightly associated with that combination
   fairly associated with that combination
   quite associated with that combination
   extremely associated with that combination

4a) Any comments related to question 4 or your response?

5) Generally, do school personnel improperly place non-White students in special education classes?
non-White students are never improperly placed
non-White students are slightly improperly placed
non-White students are somewhat improperly placed
non-White students are quite often improperly placed
non-White students are extremely often improperly placed

5a) Any comments related to question 5 or your response?

6) Do schools need a racially, ethnically, and linguistically diverse staff?
Do not need at all
Slightly need
Fairly need
Quite need
Extremely need

6-2) Which schools, if any, have a greater need for a racially, ethnically, and linguistically diverse staff and faculty?
Schools serving predominantly White students have a much greater need for a diverse staff and faculty.
Schools serving predominantly White students have a slightly greater need for a diverse staff and faculty.
All schools need a diverse staff and faculty
Schools serving predominately non-White students have a slightly greater need for a diverse staff and faculty
Schools serving predominately non-White students have a much greater need for a diverse staff and faculty

6a) Any comments related to question 6 (parts 1 and 2) or your response?

7) Can students living in economically isolated neighborhoods (i.e., most of the students attending the same school come from similar economic backgrounds) benefit socially and academically from economically integrated (i.e., socioeconomically diverse) classrooms?
Do not benefit at all
Slightly benefit
Fairly benefit
Quite benefit
Extremely benefit

7a) Any comments related to question 7 or your response?

8) Should teachers be expected to adjust their preferred mode of instruction to accommodate the needs of all students?
Not expected at all
Rarely expected
Sometimes expected
Often expected
Always expected

8a) Any comments related to question 8 or your response?

9) Do parents and families possess knowledge and expertise that can contribute to students' success at school?
No parents and families possess knowledge and expertise that can contribute to students' success at school.
A slight number of parents and families possess knowledge and expertise that can contribute to students' success at school.
A fair number of parents and families possess knowledge and expertise that can contribute to students' success at school.
A great number of parents and families possess knowledge and expertise that can contribute to students' success at school.
All parents and families possess knowledge and expertise that can contribute to students' success at school.

9a) Any comments related to question 9 or your response?

10) Can teachers' lack of knowledge about racial, ethnic, socioeconomic, and linguistic groups other than their own have a negative impact on the school experiences and academic outcomes of students who are different from the teachers?
No impact at all
Slightly impact
Fairly impact
Quite impact
Extremely impact

10a) Any comments related to question 10 or your response?

11) Is a student's academic success dependent on how hard they work to learn?
Not dependent at all
Slightly dependent
Fairly dependent
Quite dependent
Extremely dependent

11a) Any comments related to question 11 or your response?

12) Is examining one's own attitudes and beliefs about age, disabilities, gender, linguistic origin, race, religion, sexuality, and socioeconomic background an important part of learning to be a teacher?
Not at all important to examine one's attitudes
Slightly important to examine one's attitudes
Fairly important to examine one's attitudes
Quite important to examine one's attitudes
Extremely important to examine one's attitudes

12a) Any comments related to question 12 or your response?

13) Is being responsive to cultural and linguistic needs of students as important as addressing reading or mathematical abilities?
Much less important than addressing reading or mathematical abilities
Slightly less important than addressing reading or mathematical abilities
Just as important as addressing reading or mathematical abilities
Slightly more important than addressing reading or mathematical abilities
A lot more important than addressing reading or mathematical abilities

13a) Any comments related to question 13 or your response?

14) Do teachers need to consider if they derive any privilege based on their age, gender, disability status, linguistic origin, race, religion, sexuality, and socioeconomic status to be effective teachers?
No consideration is necessary at all
A little consideration is necessary
Some consideration is necessary
Quite a bit of consideration is necessary
A lot of consideration is necessary

14a) Any comments related to question 14 or your response?

15) For students who immigrate to the US from countries in which a language other than English is the dominant language, is it more important for students to be fully immersed in English in school than to spend time maintaining and developing their native language proficiency?
Much less important than maintaining native language
Slightly less important than maintaining native language
Just as important as maintaining native language
Slightly more important than maintaining native language
A lot more important than maintaining native language

15a) Any comments related to question 15 or your response?

16) Should teachers ever group students of the same ability levels together?
Never group students by ability levels
Rarely group students by ability level
Sometimes group students by ability level
Often group students by ability level
Always group students by ability level

16a) Any comments related to question 16 or your response?

17) Is helping students question gender role stereotypes when they are evident in instructional materials or within the educational setting part of the responsibilities of the teacher?
Not at all a part of teacher responsibilities
A small part of teacher responsibilities
Somewhat part of teacher responsibilities
Quite a part of teacher responsibilities
Very much a part of teacher responsibilities

17a) Any comments related to question 17 or your response?

18) Is it part of the responsibilities of a teacher to challenge school arrangements, policies, and practices that maintain social inequalities based on race, ethnicity, social class, language, and/or special needs?
Not at all a part of teacher responsibilities
Slightly part of teacher responsibilities
Somewhat part of teacher responsibilities
Quite a part of teacher responsibilities
Very much a part of teacher responsibilities

18a) Any comments related to question 18 or your response?

APPENDIX J

CURRICULUM IMPLEMENTATION OBSERVATIONS CONSENT

I am a doctoral candidate in the Arizona State University Learning, Literacies, and Technologies Ph.D. program working under the direction of Dr. Michelle Jordan. I am currently conducting research towards my dissertation. As part of that work, I am facilitating the curriculum development component of your SEER Research Experience for Teachers summer program. In order to help me prepare for my dissertation and better understand how experienced teachers create and implement culturally responsive photovoltaics engineering curricula into their classrooms to help broaden their students' participation in STEM fields, I would appreciate if you would allow me to collect data on your implementation of the engineering practices and curriculum you developed as part of the RET.

After the summer program, May – July, SEER has requested that you implement your designed curriculum during the following school year. I would like to observe your classroom (for approximately one hour), take field notes during the implementation, and receive an updated copy of the curricula (if you have revised it since the summer). Additionally, I would like to visit your classroom up to two more times during the following school year while you and your students are engaged in any engineering (or STEM) instruction or projects (whether you designed them or not). At each visit, I would like to conduct an interview with you (30 minutes or less) to learn what has been most/least beneficial from your participation in the RET program, what suggestions you have, and so on. I would like to audio record each interview, but the interview will not be recorded without your permission. Please let me know if you do not want the interview to be recorded; you also can change your mind after the interview starts, just let me know. I will not be collecting any data from any of your students.

Your choice to allow me to collect data in response to the curriculum created as part of the RET summer program is voluntary. You may decide at any time that you no longer want me to collect data from you, and there will be no penalty. For example, it will not affect your participation in the SEER Summer Program. If you do not want your data collected, information relating to you would be excluded.

There are no foreseeable risks or discomforts to your participation. Data collected from the observation and curriculum will be connected to previous data from the summer program, but the data will be de-identified after data collection is complete. The results of this study may be used in reports, presentations, or publications, but your name will not be used. If you consent to participate, your words may be quoted and your products may be shown, but your personal information will be kept confidential since data will be de-identified and pseudonyms used in published findings. We will have a master list which connects your name to your pseudonym, but this will be kept separately from raw data in order to maintain confidentiality.

If you have any questions concerning the research study, please contact me at [blinded], or my advisor at [blinded]. If you have any questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board, through the Office of Research Integrity and Assurance, at (480) 965-6788.

SEER Research Experience for Teachers (RET) Summer Program:
Curriculum Implementation Observations Consent Form

By signing your name below, you are acknowledging that you are 18 or older and are agreeing that you would like to continue to participate in this study by having your curriculum implementation observed in your classroom. You can still choose to withdraw at any time. Thank you for your consideration.

Print Name: ____

Signature:____ Date: ____________

APPENDIX K

SEMI-STRUCTURED INTERVIEW PROTOCOL: FINAL INTERVIEW

Thank you for allowing me to visit, observe, and talk with you today! This interview should take no more than 15 minutes and will focus on how your participation in the RET has influenced your curriculum and teaching practices generally and in engineering. The information you provide will be used to make modifications and improvements to the program and also to prepare reports to the National Science Foundation (NSF) on the extent to which the program has met its goals and objectives. It may also be used in research presentations and articles, but neither your name nor any other identifying information will be used.

I would like to audio record this interview. The interview will not be recorded without your permission. You also can change your mind after the interview starts; just let me know if you want to stop the interview at any time. Your participation in this interview is voluntary, and you may choose not to answer any question or to quit at any time. I anticipate that this interview will last about 30 minutes. Before we begin, do you have any questions? Do you provide your consent for me to begin recording this interview?

{IF YES, START AUDIO RECORDING}

What is your STUDY ID?

1) How has participation in the summer program influenced your work so far this school year?

   Specifically,…

   a. Your role/identity as a teacher?
   b. Your responsiveness to students in your class(es)/district?
   c. Your instructional practices?
   d. Your use of PV/engineering in your teaching?
   e. Your curricula?

2) What experiences, if any, from the summer RET have been most impactful on your work?

3) What successes and challenges have you experienced implementing your curricula?

4) What opportunities have you had as a result of participating in the RET? What opportunities are you hoping to have, or are you now aware of, as a result of the RET?

5) Is there anything else you want to share concerning your curriculum, instruction, or the summer RET experience?

APPENDIX L

SCHOOL YEAR FOLLOW-UP SURVEY

Please respond to the following nine questions to help us better understand how your experience in the SEER Summer RET Program in 2019 impacted your work during the school year and how we can continue to improve the program in the future.

Your Name:

Culturally Responsive Teaching

This past summer, we added a focus on culturally responsive teaching throughout the program to help support the National Science Foundation's goals of increasing the success and engagement of underrepresented populations (e.g., females, differently-abled individuals, individuals identifying as Native American, Latinx, or Black) in STEM courses. Culturally responsive teachers seek to make their teaching responsive to all of their students through 1) making content accessible, relevant, and representative; 2) maintaining and supporting high expectations; 3) building relationships; 4) fostering critical thinking and action around issues of social justice and equity; and 5) incorporating students' home cultures, experiences and languages as an asset to learning.

As part of this focus, Dr. Kesia Adisa presented on culturally responsive teaching, we read and discussed an article about using students' funds of knowledge in engineering instruction, and we discussed strategies (as an RET group and with Jade Whipple) for being more culturally responsive to our students. Please consider these activities and the description of culturally responsive teaching above when answering the following three questions.

1. What culturally responsive practices, if any, have you implemented or adapted this past school year? (Note: This can include specific content or lessons or general changes to classroom procedures, interactions with students, or general teaching practices.)

2. How did your students respond to the practices you listed in Question 1?

3. What barriers or challenges, if any, have you experienced in implementing (or trying to implement) culturally responsive teaching?

Engineering Curricula Implementation

Another focus of the summer program was creating PV engineering curricula to implement with your students in the classroom. The three questions in this section focus on the specific curricula (e.g., lesson plan, project) you created for your classroom.

4. During this school year, were you able to implement part or all of the lesson(s) or project you created during the summer program?
    a. Yes
    b. No
    c. Other

5. What barriers or challenges, if any, did you face in implementing your lesson(s) or project during the school year?

6. If you were able to implement, what benefits or successes, if any, did you and your students experience from your lesson(s) or project?

Other Activities and Feedback

The final three questions focus on other activities from the summer program you may have used with your students and any overall feedback about your experience.

7. What other content, lessons, or activities from the SEER summer program did you implement during this school year? Please select all that apply.
    a. Engineering/PV research work (e.g., solar cell fabrication, creating/using measuring devices)
    b. Activities with Jade Whipple and the middle school students (e.g., circuits, whiteboard work, purpose diagram)
    c. SEER lessons (e.g., Solar Carnival, construction paper solar cells, Ella the Electron)
    d. Futures Thinking activities (e.g., Variable Worlds game, narratives, nanotechnology cards)
    e. None
    f. Other

8. Please briefly explain what you did for each category you checked in the previous question.

9. Do you have any other feedback or suggestions as we continue to support you and plan future SEER RET programs?

APPENDIX M

RESET CONJECTURE MAP 3: FINDINGS

Design Features	DC →	Enactment Processes	PC →	Outcomes
Materials & Resources		**Participant Artifacts**		**O1**
8) CRT resources	A, E	F) Teacher-created, responsive science & engineering curriculum	O2	Development or strengthening of role identity as a responsive science & engineering teacher
9) Pedagogical resources	A, E			
Activity & Task Structures		**Observable Interactions**		**O2**
10) CRT Examples: Jade & YS MS	D, **E**	G) Critically evaluate key events and past experiences/practices for responsiveness/ equity	**O1**	Integration of CRT principles into science and engineering instructional practice in the classroom
11) CRT Guest Presenter: Dr. Adisa	**B, E**	H) Interactions with others as learners/ contributors	**O1**, O3	
12) Pedagogical workshops	A, E			
Participation & Practices		**Participant Experiences**		**O3**
13) Engagement as learners and contributors	**C, D**	I) Experience a responsive PD environment	**O3**	Actions as change agents & advocates of students' equitable access to and participation in science and engineering disciplines
14) Discuss examples, experiences, practices and content through a critical, culturally responsive lens	**B, D**	J) Feel empowered to enact culturally responsive science and engineering teaching	O2	

Design and Process Conjectures
Bolded = conjecture supported
Gray = conjecture partially supported or limited data
~~Strikethrough~~ = conjecture not supported

Enactment Processes and Outcomes
Solid Color = achieved
Diagonal Lines = somewhat achieved
Strikethrough = not achieved

APPENDIX N

RESET CONJECTURE MAP 4: RESET 2.0

High-Level Conjecture: Integrating a focus on the principles of culturally responsive teaching as an inherent part of learning about, engaging in, discussing, and reflecting on science and engineering research, design, and instruction will result in teachers' identity development and empowerment as advocates of and change agents for students' equitable access to and participation in science and engineering disciplines.

Design Features	DC →	Enactment Processes	PC →	Outcomes
Materials & Resources		**Participant Artifacts**		**O1**
15) CRT resources (e.g., articles, templates)	B, F	A) Teacher-created, responsive science & engineering curriculum	O2	Development or strengthening of role identity as a responsive science & engineering teacher
16) Pedagogical resources (e.g., plans)	A, F	B) CRT enactment plan	O2, O3	
Activity & Task Structures		**Observable Interactions**		**O2**
17) CRT interactions: Purposefully selected teacher(s) & students	B, D	C) Explicit connections between events and targeted shifts in role identity and practice	O1	Integration of CRT principles into science and engineering instructional practice
18) CRT awareness building: Expert presenter	C, F			
5) Pedagogical workshops	A, F	D) Engagement as a learner and a contributor	O1, O3	
Participation & Practices		**Participant Experiences**		**O3**
6) Engagement as learners and contributors	D, E	E) PD environment is responsive	O3	Actions as change agents & advocates of students' equitable access to and participation in science and engineering disciplines
7) Critical discussions through CRT lens (RESET events & role identities)	C, E	F) Increased knowledge/ability to enact equitable science & engineering instruction	O2, O3	

Design Conjecture (DC): If teachers engage in critical reflection and discussion related to pedagogical workshops, interactive CRT experiences, and their role identities as mid-career science and engineering teachers, then they will increase their awareness of equity and social justice issues impacting their students and create, evaluate, and enact culturally responsive science and engineering curriculum and practices aligned with their purposes and goals.

Process Conjecture (PC): If teachers increase their awareness of equity and social justice issues impacting their students and create, evaluate, and enact culturally responsive science and engineering curriculum and practices aligned with their purposes and goals, then they will develop or strengthen their identities as culturally responsive teachers, change agents, and advocates of students' equitable access to science and engineering disciplines and will enact culturally responsive science and engineering curricula and instruction.