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# The Intersection of Culturally Responsive Pedagogy and Engineering Design in Secondary STEM

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## Abstract

The instructional practices of the engineering design process and culturally responsive pedagogy have each garnered national attention and multiple decades of research. Findings from the respective literature bases call for educators and policymakers to integrate these two pedagogical approaches into K-12 classroom instruction. Scholars have argued that this integration would improve student engagement and academic achievement. There is a significant amount of research that supports the positive student outcomes associated with each approach, yet there remains a dearth of literature that addresses the integration of these two practices into the science and mathematics content areas. The movement around educational reform is rooted in teachers serving as learners; however, understanding how teachers learn and respond to reform is largely overlooked. The present research sought to examine the way in which teachers perceive and define integrated pedagogical approaches upon implementation. The authors utilized a comparative case study design to represent experiences of five secondary math and science teachers enrolled in graduate-level coursework and professional development on culturally responsive pedagogy and the engineering design process. Findings suggest that teachers' self-reported pedagogical beliefs acted synergistically between the two pedagogical approaches. Subsequently, participating teachers expressed a strong preference towards the enactment of an integrated pedagogy of a culturally responsive engineering design process. The present research offers valuable recommendations for teacher educators, professional development providers, policymakers, and researchers who wish to integrate culturally responsive pedagogy and the engineering design process in math or science K-12 classrooms. The significance of this research underscores the importance of empowering teachers with professional development, around implementation of novel pedagogical approaches, to both shape and inform their beliefs and practices.



## Keywords

engineering design, culturally responsive pedagogy, STEM teachers, case study

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# The Intersection of Culturally Responsive Pedagogy and Engineering Design in Secondary STEM

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**Abstract**

The instructional practices of the engineering design process and culturally responsive pedagogy have each garnered national attention and multiple decades of research. Findings from the respective literature bases call for educators and policymakers to integrate these two pedagogical approaches into K-12 classroom instruction. Scholars have argued that this integration would improve student engagement and academic achievement. There is a significant amount of research that supports the positive student outcomes associated with each approach, yet there remains a dearth of literature that addresses the integration of these two practices into the science and mathematics content areas. The movement around educational reform is rooted in teachers serving as learners; however, understanding how teachers learn and respond to reform is largely overlooked. The present research sought to examine the way in which teachers perceive and define integrated pedagogical approaches upon implementation. The authors utilized a comparative case study design to represent experiences of five secondary math and science teachers enrolled in graduate-level coursework and professional development on culturally responsive pedagogy and the engineering design process. Findings suggest that teachers' self-reported pedagogical beliefs acted synergistically between the two pedagogical approaches. Subsequently, participating teachers expressed a strong preference towards the enactment of an integrated pedagogy of a culturally responsive engineering design process. The present research offers valuable recommendations for teacher educators, professional development providers, policymakers, and researchers who wish to integrate culturally responsive pedagogy and the engineering design process in math or science K-12 classrooms. The significance of this research underscores the importance of empowering teachers with professional development, around implementation of novel pedagogical approaches, to both shape and inform their beliefs and practices.

*Keywords:* engineering design, culturally responsive pedagogy, STEM teachers, case study

## Introduction

The purpose of this comparative case study is to investigate teacher beliefs and sense of agency upon implementing new instructional practices; specifically teaching secondary science or mathematics content infused with the engineering design process (EDP) (Katehi et al., 2009) and culturally responsive pedagogy (CRP) (Ladson-Billings, 2009). Currently, K-12 schooling in the USA lacks exposure to the appreciation and knowledge surrounding the creativity, rewarding work, and positive learning outcomes associated with science, technology, engineering, and mathematics (STEM)-related careers (Katehi et al., 2009). This lack of exposure especially limits women and people of color, both of whom are underrepresented in STEM fields (Katehi et al., 2009; National Science Board, 2016). As such, while the need for improving the success rates

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in STEM coursework is pertinent across all racial and ethnic backgrounds, it is especially critical to address the needs of students from historically minoritized populations that are disproportionately less likely to pursue and persist through STEM-related degree programs (Leboy & Madden, 2012).

One strategy for reform in improving participation in STEM fields is aimed towards K-12 pedagogies in math and science classrooms. Shifts in instructional practices are grounded within the beliefs or *agentic behaviors* of teachers as the guiding force behind their instructional decisions and actions (Pajares, 1992; Rokeach, 1968; Siwatu, 2007). There is a substantial amount of research on the topics of the EDP and culturally responsive teaching suggesting that the pedagogical approaches result in positive student outcomes (Gay, 2000; Katehi et al., 2009; Ladson-Billings, 2009). However, the response, beliefs, and understanding that teachers have about these pedagogies have been largely overlooked (De Florio, 2016). Accordingly, the crux of the present research is grounded in the value of examined secondary mathematics and science teachers' beliefs regarding the pedagogical approaches of EDP and CRP. Moreover, through the study of teachers' agentic behaviors, the present research study provides insights into the barriers that teachers may encounter when integrating EDP and CRP pedagogies.

This study was conducted through the lens of Bandura's social cognitive theory and is driven by the assertion that individuals are capable of influencing decisions, functions, and behavior with intentionality (Bandura, 1986, 2001, 2006), known as agency. Humans' beliefs are at the core of their agentic behaviors, which includes self-regulated behaviors that allow an individual to take the necessary actions to yield desired outcomes (Bandura, 2006). These agentic behaviors include intentionality and forethought to guide the plans for action, as well as self-reactiveness and self-reflection which allow for one to persevere through challenges and self-examine their progress (Bandura, 2001). Acknowledging that an individual's sense of agency leads them to actively regulate their own experiences provides an ideal lens from which to examine teacher agency and their pedagogical beliefs. The following research question was informed by the theoretical underpinnings of Bandura's (1986, 2001) social cognitive theory:

*RQ 1. How, and in what ways, are secondary mathematics and science teachers' pedagogical beliefs and sense of agency related to the integration of the EDP and CRP in the classroom?*

*RQ 1a. What barriers do secondary mathematics and science teachers experience during implementation of CRP and EDP?*

*RQ 1b. How do secondary mathematics and science teachers perceive their own role in the movement to implement CRP and EDP in secondary science and mathematics curricula?*

## Literature Review

Both CRP and EDP have each garnered national attention and multiple decades worth of research (Gay, 2010; Katehi et al., 2009; Ladson-Billings, 2009; Lee & Fradd, 1998; Wulf, 1998). The findings from these bodies of literature urge the integration of these two pedagogies into K-12 instruction to support inclusive STEM curricula (Crismond, 2001; Kolodner et al., 2003; Mehalik et al., 2008), greater student interest, and improved academic achievement (Aguirre & del Rosario Zavala, 2013; Lachapelle & Cunningham, 2014).

The EDP is a critical component of the work engineers do and how they approach societal problems. EDP has been defined as an approach encompassing identification of a problem and developing a model that is refined through data analysis to produce a solution consisting of social and technological elements (Daugherty & Custer, 2012; Hynes et al., 2011). According to Katehi et al. (2009), EDP is in essence, "the central activity of engineering" (p. 56). Wulf (1998) explained that engineers regularly tackle problems through consideration of limitations and constraints (i.e., cost, time, materials, etc.) to derive solutions that cater to human wants and needs. Hence, EDP identifies a problem and works towards the design of a viable solution through an iterative set of practices (Apedoe et al., 2008). Although the order of these practices may vary, the EDP encompasses a series of critical steps aimed at addressing a specific problem (Atman et al., 1999). The process of engaging in the EDP is initiated by identification of a need or problem (Apedoe et al., 2008) often expressed through concerns of customers or clients (Crismond et al., 2006). Following this step, engineers explore similar, previously solved, problems, while being mindful of constraints and limitations. This research phase is critical because it allows engineers to acquire a deep understanding of how the problem being tackled relates to those previously resolved. The process of re-design and re-testing provides engineers with useful insights about the physical constraints and limitations of the problem or product. Furthermore, the practice of evaluation, which can take place at any point in the design, allows engineers to obtain feedback, as well as generate ideas for upcoming redesign procedures (Crismond et al., 2006).

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Therefore, the redesign stage is instrumental to the process as it allows engineers to refine the prototype through informed decisions based on data collected and feedback acquired during testing and evaluations (Apedoe et al., 2008).

Carr and Strobel (2011) advocated that the integration of the EDP connects mathematics and science content in meaningful ways for K-12 learners, which may help explain that inclusion of EDP resulted in improved student achievement and interest in STEM fields (Katehi et al., 2009). However, according to Lee and Strobel (2014), while preservice teacher preparation and in-service teacher professional development on scientific inquiry gained traction in STEM education reform, the EDP did not receive the same level of attention. The authors believed that this discrepancy was a result of an already established foundation for the sciences in K-12 curricula. Thus, an increased emphasis must be placed on teacher preparation and professional development programs (Brophy et al., 2008; Lee & Strobel, 2014; Roehrig et al., 2012).

An essential feature of the EDP is to identify a problem akin to real-world challenges (Apedoe et al., 2008; Crismond et al., 2006; Hynes, 2010). Yet, there is a dearth of literature on the need for framing those problems through *culturally relevant* real-world challenges. Ladson-Billings (1994, 1995) coined this term during her exploration of the instructional practices used by teachers to effectively teach students of color in a way that builds on their lived experiences. Ladson-Billings stated that CRP is a philosophy of teaching that asserts the need to use students' cultural identities and experiences as resources for classroom instruction. CRP is "a pedagogy that empowers students intellectually, socially, emotionally, and politically by using cultural referents to impart knowledge, skills, and attitudes" (Ladson-Billings, 1994, p. 382). The implications of tailoring instruction to reflect the culture of ethnically diverse students includes positive learning outcomes of underrepresented minority populations (Hollins, 1996; Ladson-Billings, 1994, 1995). Cultural characteristics are inclusive of students' ethnic background and traditions. These traits include varying forms of learning styles, societal contributions, communications, and gender role socialization, all of which are influenced by cultural factors (Gay, 2000). Accordingly, teachers must move past the faulty ideology of a one-size-fits-all instructional approach and, instead, adopt a methodology that envisions content through their students' cultural lens (Aguirre & del Rosario Zavala, 2013; Gay, 2000, 2002, 2010). The embodiment of CRP demands that teachers share content knowledge in meaningful ways, while also creating avenues for students to challenge the systemic issues in society.

The Ladson-Billings (1994, 1995) model for CRP is built upon three fundamental pillars: academic achievement, cultural competence, and sociopolitical consciousness. The first tenet asks instructors to foster an environment that is inclusive of the instructional practices intended to help students master the content. Teachers who were able to effectively teach students of color upheld a sense of responsibility towards preparing students to be academically successful. Ladson-Billings (1994) further explained that the embodiment of CRP "requires that teachers attend to students' academic needs, not merely make them feel good" (p. 160). In her later work, Ladson-Billings (2006) explained that academic achievement does not equate to student achievement on high-stakes testing. Instead, she shared that her vision for the tenet entails learning that occurs through interactions with skilled teachers. The second tenet of CRP tasks teachers to design learning experiences that celebrate the social, cultural, and linguistic background of their students. In doing so, teachers reject deficit-thinking when working with students of color and, instead, view the culture and lived experiences of students as assets to their learning. Consequently, teachers who embrace cultural competence affirm and celebrate their students' cultural identities. The third tenet of CRP aims to develop the sociopolitical and critical consciousness of students. Teachers who integrate CRP in their classrooms cultivate opportunities for students to engage in academic discourse and activities that challenge the power dynamics within their communities. Hence, students are empowered to question the social inequities they may have personally experienced or witnessed. This tenet also suggests that teachers develop their own sociopolitical consciousness. However, scholars in the field of CRP have acknowledged that teachers often struggle with doing so; therefore, they only implement the first two of the three total tenets (Gay & Howard, 2000).

In sum, there remains a gap in the research on teachers' beliefs and agentic behaviors when integrating EDP and CRP in the science and mathematics classroom. Thus, the findings from this study aim to spark future investigations and discussions on the power of a culturally responsive engineering design approach to teaching along with the agency of teachers who are employing these practices. As such, this work also contributes to the literature on teacher agency, a developing and important field in the realm of teacher education research that is scarcely explored and reported (Biesta et al., 2015; Cheng & Huang, 2018; Vähäsantanen, 2015).

## Methodology

Teachers for this study were recruited from a National Science Foundation (NSF)-funded, five-year fellowship program at the University of Houston, *Leadership through Equity and Advocacy Development* (LEAD) *Houston*. A cohort of 15 teachers participated who were enrolled in a master's degree in STEM education and had four subsequent years of professional development. The five teachers selected from the cohort shared plans for incorporating CRP and EDP during the upcoming school year. This research utilized a study design (Merriam, 1998) that employed mixed methods for the data collection (Creswell, 2014). Each participant comprised an individually bounded case (Stake, 1995) and the data collected from each case were triangulated and analyzed within and across each case. The data consisted of submitted reflective journal entries regarding their perceptions and beliefs about the implementation process, philosophy of teaching statements, and transcripts from individual interviews. Member checking through synthesis of analyzed findings (Stake, 1995) was facilitated as an additional and final data source. Saldaña's (2013) coding techniques were utilized to identify emerging themes for individual teachers and again through a thematic analysis to identify meta-patterns across cases. The findings from the qualitative data were combined with quantitative results derived from the Design, Engineering, and Technology (DET) survey (Yaşar et al., 2006), and the Culturally Responsive Teaching Outcome Expectancy (CRTOE) survey (Siwatu, 2007). During cross-case analysis, descriptive statistics acquired from the quantitative instruments helped corroborate teachers' beliefs and agentic behaviors when integrating EDP and CRP in their content instruction. Table 1 provides an overview of the data sources and analyses to redress the research inquiry. The data collected include quantitative surveys for each approach: EDP and CRP.

### *Qualitative Data Collection*

Each participant was asked to complete a 10- to 15-minute reflective journal prompt. Teachers were asked to spend an estimated 100–150 minutes total to complete ten short-answer journal prompts. These entries were completed following the implementation of the instructional module inclusive of CRP and the EDP. Reflective journals are utilized in research to provide participants and researchers with an avenue for expressing thoughts and narrating experiences (Connelly & Clandinin, 1990). In the context of teacher education, reflective journaling strengthens relationships between the instructor and trainee (Bashan et al., 2017), and improves the learning process of teaching candidates (Moon, 2000). According to Farabaugh (2007), reflective journaling promotes awareness of the process through recording thoughts and feelings associated with each aspect of the learning process. Moreover, journaling allows the learner to connect theory with practice (Dyment & O'Connell, 2011).

In addition to reflective journaling, the data collected were also triangulated with the findings attained through semi-structured individual interviews. Each interview lasted approximately one hour and took place after the teachers completed their reflective journal prompts and surveys. Semi-structured interviews help provide a naturalistic environment that enables interviewees to openly discuss their thoughts and ideas (Krueger & Casey, 2000). Furthermore, unlike the generalizations caused by only using surveys, interviews yield insights into human behavior and perceptions (Fern, 2001). Doing so allowed the authors to strategically pose interview questions guided by the responses obtained through the other data sources. The interview protocol refinement (IPR) framework (Castillo-Montoya, 2016) was utilized to strengthen the reliability of the interview protocols as shown in Table 2.

The first step of the IPR for interview protocol development mapped the interview questions onto a matrix of the key constructs of the framework. A few additional questions were added to obtain background information regarding the participants' school setting. The next phase of the framework suggests that the researcher construct an inquiry-driven conversation with the interviewees. Maxwell (2013) explained that this entails composing the interview questions differently from the research questions by stating that "research questions formulate what you want to understand; your interview questions are what you ask people to gain that understanding" (p. 101). Thus, the authors of this study utilized everyday language of the interviewees in the questions, and avoided the theoretical language often utilized in writing

Table 1
List of research inquiry, data sources, and data analysis.

| Research inquiry | Data sources | Data analysis approach |
|---|---|---|
| Pedagogical beliefs about the EDP and CRP | Quantitative: CRTOE (Siwatu, 2007) and DET (Yaşar et al., 2006) surveys<br>Qualitative: reflective journals; interviews | Descriptive analysis<br>Three rounds of content analysis: first cycle (*in vivo*), second cycle (*in vivo* and values), and third cycle (pattern) coding methods |
| Barriers encountered during implementation of EDP and CRP | Quantitative: DET survey<br>Qualitative: reflective journals; interviews; member checking | Descriptive Analysis<br>Content analysis: three rounds of content analysis: first cycle (*in vivo*), second cycle (*in vivo* and descriptive), and third cycle (pattern) coding methods |
| Perceived role in implementation of EDP and CRP in content area | Teaching philosophy statements; interviews; reflective journals; member checking | Three rounds of content analysis: first cycle (*in vivo*), second cycle (*in vivo* and descriptive), and third cycle (pattern) coding methods |

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Table 2
Four steps to interview protocol refinement.

| Step # | Protocol action |
|---|---|
| 1 | Alignment of interview questions with research questions |
| 2 | Developing an inquiry-based dialogue |
| 3 | Acquiring feedback on the interview protocol |
| 4 | Piloting the interview protocol |

*Note.* Adapted from Castillo-Montoya (2016).

Table 3
Sample excerpt from interview matrix.

| Interview question | Background information | Teacher agency | Teacher beliefs |
|---|---|---|---|
| Transition statement: *I'd like to begin the interview by first asking you some questions regarding your school and/or district.* | | | |
| Q1. Can you describe your school setting for me? | X | | |
| Q2. How long have you been teaching at this school/district? | X | | |
| Transition statement: *Great. Next, I'd like to discuss your perceptions about the constructs of engineering design process (which I will abbreviate as EDP) and culturally responsive pedagogy (which I will abbreviate as CRP).* | | | |
| In your reflection journal you described how you used EDP to augment your project by <*insert description*> | | X | X |
| Q3a. How do you define EDP in your classroom context? | | | |
| Q3b. How did the infusion of EDP change this project? | | | |
| Q3c. Do you see room for infusing EDP pedagogy in other curricular projects you are currently using? | | | |
| In the reflection journal, you described how you used CRP to augment your project *by* <*insert description*> | | X | X |
| Q4a. How do you define CRP in your classroom context? | | | |
| Q4b. How did the infusion of CRP change this project? | | | |
| Q4c. Do you see room for infusing CRP pedagogy in other curricular projects you are currently using? | | | |
| Q5. What connection/s have you made between EDP and CRP? Please describe the connections you see or lack thereof. | | | X |

*Note.* Adapted from Castillo-Montoya (2016).

research questions (Brinkmann & Kvale, 2015). Moreover, to conduct a conversational dialogue that still maintains the goals of the research, the authors utilized four types of interview questions recommended by researchers: (1) introductory; (2) transitional; (3) key or integral; and (4) closing questions (Castillo-Montoya, 2016; Creswell, 2008; Krueger & Casey, 2009; Merriam, 2009). The third phase ensures that reliability and trustworthiness of the interview protocol are strengthened by obtaining feedback. This was provided by an additional mixed-methods researcher who is involved with the NSF grant that funds the fellowship. For the fourth and final phase, a pilot interview was conducted with an educator not associated with the fellowship grant only to pilot instrument (Baker, 1994; Merriam, 2009). Still, while the pilot was not conducted with a group of participants or someone associated with the fellowship, it is important to note that according to Castillo-Montoya (2016) many researchers may only be able to carry out the first three phases of the IPR process. Castillo-Montoya explained that this may be due to a lack of access to resources, time, or willing participants, nevertheless, "those researchers have taken important steps to increase the reliability of their interview protocol as a research instrument and can speak to that effort in their IRB applications as well as any presentations or publications that may result from their research" (p. 827). Consequently, this research utilized IPR to develop interview questions that elicit insightful responses with strategic alignment to the research purpose and were conducted through a protocol that strengthens the reliability and trustworthiness of the research. Table 3 displays a sample of the interview questions with cells marked to indicate which construct of the research is being addressed through each question (Neumann, 2008).

In addition to interviews and reflection journals, the participants also provided their teaching philosophy statements. These statements generated an additional self-reported data source that gave insights regarding the teachers' agency along with how they perceive their role in educational reform. The statements were analyzed for alignment with the teachers'

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reflections and reactions to the implementation of new instructional practices. Thus, their philosophy on teaching helped support and explain their agentic behaviors and beliefs.

*Member Checking*

Member checking can take place at different points in data collection and can often include sending the transcript of an interview to the participants (Doyle, 2007). The approach utilized in this research provides the participants with a more involved role in the process of telling their story. Member checking through synthesis of analyzed data (Harvey, 2014) allowed participants to read through the researchers' interpretations of their statements. In this case, the interpretations include results and findings from surveys, interviews, reflection journals, and teaching philosophy statements. As explained by Birt et al. (2016), "if studies are undertaken to understand experiences and behaviors and to potentially change practice, then surely participants should still be able to see their experiences within the final results" (p. 1805). This approach complements a constructivist approach for data analysis as it allows the participants to reflect upon their own responses and stories while having the opportunity to add more data, help validate the findings, and minimize researcher bias in interpretation (Birt et al., 2016; Doyle, 2007).

*Quantitative Data Collection*

In an effort to investigate the beliefs teachers hold regarding EDP the participants were asked to complete the quantitative DET survey. Yaşar et al. (2006) developed a quantitative instrument to assess the perceptions K-12 teachers hold regarding teaching with DET. DET was defined to include the following characteristics: identifying a problem vis-a-vis technology, proposing solutions by understanding cost–benefit rations, selecting a solution based upon limiting parameters, implementing with a model, and using the solution as a form of communication. The authors explained that the combination of the design, engineering, and technology approaches allows for "conceiving, building, maintaining, and disposing of useful objects and/or processes in the human-built world" (Yaşar et al., 2006, p. 205). The authors further related their definition of technology to that established by the national science standards. As such, DET was defined to include the following characteristics which also mirror the practices outlined by the Massachusetts Department of Education (DOE) (2016) along with other prominent EDP models:

> identify a problem or a need to improve on current technology; (2) propose a problem solution; (3) identify the costs and benefits of solutions; (4) select the best solution from among several proposed choices by comparing a given solution to the criteria it was designed to meet; (5) implement a solution by building a model or a simulation; and (6) communicate the problem, the process, and the solution in various ways. (Massachusetts DOE, 2016, p. 205)

For the purpose of examining teacher beliefs regarding CRP, this study utilized the CRTOE scale (Siwatu, 2007). As is true for the theoretical foundation of this research, Siwatu (2007) was also guided by Bandura's (1977, 1986) theoretical lens of social cognitive theory. Siwatu (2007) differentiated between the self-efficacy and outcome expectancy scale, the latter of which is used for this study, by explaining that outcome expectations "are individual judgments about the potential outcomes of their behaviors" (p. 1088). Siwatu (2007) asserted that the competencies selected for the instruments are rooted in literature that reflects the voices of practitioners and pioneers in research who have advocated for the culturally sensitive and relevant teaching practices that associated closely with a CRP approach. The author noted that these instruments were developed due to shortage of scales that measure preservice or practicing teacher beliefs regarding CRP: "despite the changing demographics of today's schoolchildren, little research has been done to examine preservice and in-service teachers' culturally responsive teaching self-efficacy and outcome expectancy beliefs. The development of the CRTSE and CRTOE would allow for these needed inquiries" (Siwatu, 2007, p. 1089). Both surveys were administered to teachers completing their lessons infused with EDP and CRP.

*Data Analysis*

Cases were analyzed using a concurrent triangulation design (Creswell, 2008; Creswell & Plano-Clark, 2007), which warrants collecting and analyzing the quantitative and qualitative data concomitantly within and across the cases. The triangulation design is the most commonly used approach in mixed-methods research as it allows the investigator "to obtain different but complementary data on the same topic" (Morse, 1991, p. 122), thus achieving a deeper understanding of the topic or problem. The convergent model of triangulation design (Creswell, 1999) allows the researcher to compare results derived from quantitative and qualitative approaches in order to validate, confirm, and corroborate the qualitative findings and with quantitative results (Creswell, 2008). In the present research, the authors examined teacher beliefs regarding the implementation of the EDP and CRP approaches through multiple lenses and further verified the findings across the cases (Creswell, 2014). Consequently, this research employed the mixed methods triangulation approach to corroborate participants' survey results (quantitative) with interview transcripts, reflective journal responses, and teaching philosophy statements (qualitative) to better understand the beliefs and agency of secondary mathematics and science teachers upon implementing EDP and CRP in their respective content (math or science) instruction.

This research utilized an inductive approach (Saldaña, 2013) for coding that minimized researcher bias through the search for prescribed themes, and yielded an exploratory study that allowed the participants to drive the findings. All the qualitative data sources (i.e., interviews, reflection journals, and teaching philosophy statements) underwent three rounds of coding in an effort to establish rigor in the analysis and thoroughly derive the emerging themes. The first round involved *in vivo* coding which is at times referred to as *natural* or *emic* coding, implying that it involves the inductive approach for coding verbatim terms or phrases used by the participant. Saldaña (2013) explained that this approach is most appropriate when the study prioritizes the participant's voice in the data analysis process.

The second round of coding utilized both *in vivo* and *values* coding methods. Values coding has been described by Saldaña (2013) as "the application of codes to qualitative data that reflect a participants' values, attitudes, and beliefs, representing his or her perspectives or worldview. Though each construct has a different meaning, values coding, as a term, subsumes all three" (p. 131). Values coding was appropriate for this research not only because it focuses on an individual's beliefs, a pivotal feature of this research, but, also, because it is recommended for case studies. Furthermore, values coding, when applied to multiple data sources, helps corroborate the coding and strengthen trustworthiness (LeCompte & Preissle, 1993; Saldaña, 2013). Finally, the third and final round of coding utilized a second-cycle coding method, *pattern coding*. Second-cycle coding allows researchers to "reorganize and reanalyze the data coded through first cycle methods" (Saldaña, 2013, p. 234). Specifically, pattern coding is utilized to *meta code* or group similarly identified codes, while also ascribing meaning to the newly organized categories or emergent themes. Thus, pattern codes combine the data from first-cycle coding and synthesizes it into more meaningful units of analysis (Miles et al., 2014; Saldaña, 2013).

The quantitative data analysis consisted of utilizing the descriptive data collected through surveys. In addition to the survey responses, this includes teachers' demographic information, such as gender, age, race, number of years of teaching experience, certification, secondary grade level, and content area. Moreover, descriptive statistics for the schools in which each participant taught are also presented which includes demographic data of the student population. The descriptive data were triangulated with the qualitative findings for analysis within and across each case.

## Findings

The five identified cases consisted of teachers with experience ranging from 6 to 13 years in the classroom, as shown in Table 4. Four of the participants are science teachers while one teaches mathematics. Moreover, three of the participants are middle school teachers and two teach high school. Three of the teacher participants have bachelor's degrees in their content area while the other two have background in education or interdisciplinary studies.

Of the five cases included in this study, four teachers identified as female. Three participants identified as Hispanic while the other two identified as Non-Hispanic/White. Table 5 shows the combinations of gender and race/ethnicity included in this study.

Table 6 shows the characteristics of the schools and districts in which the five participants are currently teaching. All, with the exception of one, teacher participants work for schools with over 40% of the student population classified as economically disadvantaged, a designation indicating that a student is eligible for free or reduced-price meals under the National School Lunch and Child Nutrition Program (Texas Education Agency, 2014). These schools also house over 50% of students identified as part of minority populations.

### *Culturally Responsive Teaching Outcome Expectations*

The CRTOE survey (Siwatu, 2007) is designed to provide insight into the set of beliefs that teachers hold about the positive outcomes associated with culturally responsive teaching practices. The survey is a self-reported measure whereupon teachers rate the possibility of positive student outcomes achieved through 26 culturally responsive instructional techniques. The teachers rate each strategy on a scale from zero which is indicative of "entirely uncertain" to 100 which implies "entirely certain." Siwatu (2007) developed the survey and described the items as a measure of "teachers' beliefs that engaging in culturally responsive teaching practices will have positive classroom and teaching outcomes" (p. 1090). Therefore, high scores on the CRTOE scale reflect greater beliefs associated with positive outcomes that result from culturally responsive instruction. Table 7 includes the participating teachers' mean scores.

The CRTOE survey (Siwatu, 2007) scores for teachers in this research ranged from 2330 to 2595 out of a maximum possible score of 2600. The teachers had a mean ($M$) score of 2532.60 and standard deviation (SD) was 273.72. The item

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Table 4
Teacher participants' educational profiles.

| Teacher | Number of years teaching | Grade level | Content area | Bachelor's degree |
|---|---|---|---|---|
| Ashley | 9 | 6–8 | Science | Interdisciplinary studies |
| Karen | 13 | 6–8 | Science | Education |
| Michelle | 4 | 6–8 | Science | Biological sciences |
| David | 6 | 9–12 | Science | Kinesiology |
| Sophia | 11 | 9–12 | Mathematics | Mathematics |

*Note.* Educational profile data were collected from survey and interview responses.

Table 5
Self-reported teacher demographics.

| Teacher | Gender | Self-identified race or ethnicity |
|---|---|---|
| Ashley | Female | Hispanic |
| Karen | Female | Non-Hispanic/White |
| Michelle | Female | Hispanic |
| David | Male | Hispanic |
| Sophia | Female | Non-Hispanic/White |

*Note.* Data reported were collected from demographic survey questions.

Table 6
Teachers' school characteristics.

| Teacher | School type | School minority Pct. | School Eco Dis. Pct. | District minority Pct. | District Eco Dis. Pct. |
|---|---|---|---|---|---|
| Ashley | 6–8 | 59.0% | 49.4% | 67.0% | 56.0% |
| Karen | 6–8 | 32.1% | 7.9% | 48.2% | 28.8% |
| Michelle | 6–8 | 96.2% | 82.5% | 67.0% | 56.0% |
| David | 9–12 | 75% | 46% | 78.4% | 77.1% |
| Sophia | 9–12 | 78.1% | 97.6% | 94.4% | 80.3% |

*Note*. Pct., percentage of total; Eco Dis., economically disadvantaged. All data are reported by schools to the government based on the 2015–2016 school year and accessed through U.S. News Education (2019).

Table 7
Teacher mean scores on the CRTOE survey.

| Teacher | Mean score |
|---|---|
| Ashley | 2548.00 |
| Karen | 2453.00 |
| Michelle | 2337.00 |
| David | 2595.00 |
| Sophia | 2330.00 |

that yielded the highest level of positive teaching outcomes expectation was for the possibility that "students' self-esteem can be enhanced when their cultural background is valued by the teacher" ($M = 98.40$; SD = 2.06).

Teachers also expressed high levels of outcome expectancy for the following possibilities: "students' academic achievement will increase when they are provided with unbiased access to the necessary learning resources" ($M = 98.20$; SD = 1.94); "providing English language learners with visual aids will enhance their understanding of assignments" ($M = 98.20$; SD = 2.23); "connecting my students' prior knowledge with new incoming information will lead to deeper learning" ($M = 98.20$; SD = 1.83); and "a positive teacher–student relationship can be established by building a sense of trust in my students" ($M = 98.20$; SD = 1.83). The last statement was also the highest scored item for Siwatu (2007) who developed the survey and measured the beliefs of 275 preservice teachers.

Meanwhile, the teachers' CRTOE beliefs were lowest for the possibility that "simplifying the language used during the presentation will enhance English language learners' comprehension of the lesson" ($M = 84.40$; SD = 15.47). This was

Table 8
Teacher scores on the DET survey.

| Teacher | Mean score |
|---|---|
| Ashley | 112.00 |
| Karen | 110.00 |
| Michelle | 113.00 |
| David | 112.00 |
| Sophia | 114.00 |

also the item with the highest level of standard deviation with a minimum score of 65 and the maximum score of 100. The next lowest scored item for outcome expectancy was "matching instruction to the students' learning preferences will enhance their learning" ($M = 88$; SD = 10.18).

### *Design, Engineering, and Technology*

The DET instrument (Yaşar et al., 2006) was developed to measure teacher perceptions of teaching with engineering design. The responses regarding barriers encountered helped provide a deeper understanding of what teachers expect to self-react towards as part of agency when implementing a project inclusive of the EDP. It is interesting to note that teachers displayed the highest level of variation on the responses regarding barriers in integration DET. Specifically, statements 22–24 each garnered a mean of 3.2 and SD of 1.09 with responses ranging from 4 (maximum) to 2.00 (minimum) on a 5-point scale. This variation is striking when considering that on all other questions the mean value was 4.60 or higher, and SD was 0.55 or lower. Moreover, 10 questions out of the total 24 resulted in a mean value of 5 (SD = 0). An additional nine questions resulted in mean of 4.80 (SD = 0.45). Lastly, the survey also resulted in one question each for mean value of 4.60 (SD = 0.55) and mean value of 4.0 (SD = 0). Statements 22–24 questioned how strongly teachers agree or disagree upon whether the lack of administrative support is a barrier when implementing DET. The statements also questioned how strongly teachers agree or disagree with "minorities and women" being perceived by others as populations who do well in DET. This variation may be suggestive of teachers' personal experiences, along with those reported from their students who belong to these underrepresented populations in STEM. Table 8 provides the total scores and mean values for each teacher participant. The scores ranged from 110 to 114, out of a maximum possible score of 120.

### *Pedagogical Beliefs about CRP and EDP*

Through reflective journals and individual interviews, teachers shared their definitions of CRP and the EDP. The definitions provided remained consistent within each individual's data sources and were also common in language across the participants. Teachers explained the EDP as an iterative cycle encompassing the following steps: identifying a problem, brainstorming solutions, designing prototypes, and redesigning to address the problem at hand (Baker, 1994; Katehi et al., 2009; Yaşar et al., 2006). CRP was defined by teachers as an approach centered on students' cultural backgrounds and lived experiences that contribute to students' funds of knowledge which are then integrated into instructional content lessons (Aguirre & del Rosario Zavala, 2013; Gutiérrez, 2009; Siwatu, 2007, 2011). The common language and description of the constructs are expected because the teachers shared their introduction to the pedagogical approaches through the graduate-level coursework as part of their master's degree program. Still, upon completion of summer courses, each teacher returned to their individual school/district and implemented the CRP and EDP to fit their content curricula. In doing so, teachers experienced varying levels of support from team members and administrators at their schools as shared through reflective journals and during interviews.

The most critical factor influencing teachers' beliefs and agency was the reaction of their students towards the projects infused with CRP and EDP. The teacher participants reported heightened interest in content, student engagement, and improved academic performance. Teachers felt encouraged by the positive learning outcomes and were driven to continue future implementation. They viewed their students' reactions as a benchmark to assess their own effectiveness with the enactment of EDP and CRP. Moreover, upon successful implementation and receiving positive student feedback, the teachers felt empowered in their capacity to advocate for others to use CRP and EDP. As such, an important take-away for teacher educators is framing the introduction of instructional practices through the lens of student outcomes.

### *The Engineering Design Process*

The definitions that teachers provided for the EDP were consistent with those rooted in the literature (Hynes et al., 2011; Yaşar et al., 2006). The teachers described the steps which include defining the problem (Cross & Roozenburg, 1993), researching solutions, identifying constraints, building prototypes, testing, redesigning, and communicating solutions (Massachusetts DOE, 2016). One of the participants, Michelle, discussed helping her students acknowledge the value in their prototypes even when the products did not function properly. She shared that she had her students verbalize all the ways in which their prototype was successful and reflect on lessons learned along the way. This is in alignment with research that argues the EDP can foster a sense of perseverance in students through the design and redesign steps involved in the experience (Lottero-Perdue & Parry, 2017). The iterative nature of engineering design assumes that the first few prototypes will not function successfully or provide the best solution to the identified problem (Cunningham & Carlsen, 2014). This process of failing and moving forward is productive as students and engineers learn and obtain data through trial (Lottero-Perdue & Parry, 2017). Petroski (2012) explained the role of failure in the field of engineering and the EDP: "…because every successful design is the anticipation and obviation of failure, every new failure no matter how seemingly benign presents a further means towards a fuller understanding of how to achieve a fuller success" (p. 45).

Thus, the experiences acquired through the EDP encourage students and teachers to embody a growth mindset, defined by Ricci (2013) as "a belief system that suggest one's intelligence, or skills, or talents, can be grown or developed with persistence effort, and focus on learning" (p. 3). Growth mindset has proven to yield positive student learning outcomes through enhanced academic performance (Blackwell et al., 2007). The EDP cultivates a growth mindset through student engagement with "test to failure experimentation" (Lottero-Perdue & Parry, 2017, p. 50). Accordingly, the *Framework for K-12 Science Education* has specifically included testing for failure as one of the core ideas found in K-12 science and engineering practices (National Research Council, 2012).

All the teacher participants stated that they observed high levels of student engagement and creativity during the course of the projects. Overall, the teachers found themselves pleasantly surprised regarding the increase in student involvement through participation in the EDP. David expressed that the feedback from his students led him to wish that he had learned about, and incorporated, EDP earlier in his teaching career. Similarly, all teacher participants also shared that they witnessed heightened levels of engagement in students who otherwise lacked interest in daily instruction. Therefore, due to the creativity and student ownership resulting from the EDP projects, students were more likely to experience positive attitudes towards content topics (Goeser et al, 2009).

David discussed a student in his class who was deeply immersed in the sketching and development of her prototype designs. However, David noted that after the project concluded, this student returned to previous behavioral characteristics, which meant lower levels of engagement and involvement in the classroom. Hence, the utilization of the EDP as a vehicle for teaching mathematics or science content provided a hands-on alternative to routine-based, traditionalistic teaching practices (Hynes et al., 2011). Furthermore, the iterative nature of EDP naturally allowed for the incorporation of scientific reasoning and mathematical problem-solving (Blackwell et al., 2007; Lachapelle & Cunningham, 2014). Consequently, the secondary mathematics and science teacher participants in this research affirmed the positive student outcomes associated with the EDP. These beliefs were also reflected in the overwhelmingly positive responses expressed by the teachers regarding future use of the recently implemented project along with future integration of the EDP in their content curricula.

### *Culturally Responsive Pedagogy*

When asked to define CRP all teachers emphasized the value in learning about their students' backgrounds. The teachers explained that doing so would allow them to tailor their instruction by connecting the students' lived experiences to content topics. This concept of building relevance with students is an integral component mentioned in scholarly definitions of CRP (see Gay, 2002; Ladson-Billings, 1994, 2009; McAllister & Irvine, 2002). Sophia shared that she planned to survey her students to use specific pieces of their cultural and family background into her projects. This is reminiscent of the community mapping project described by Jackson and Boutte (2018). Community mapping is an activity through which current and prospective teachers can include walks around the neighborhood and engage in conversations with local residents. The purpose of the exercise is to provide teachers with insights about students' culture and their life experiences outside of school (Jackson & Boutte, 2018). The value of cultivating relevance is grounded in CRP research and was prevalent in this dissertation study through the teacher participants' responses about their beliefs. This was also evidenced through the teachers' high scores and mean values resulting from the CRTOE survey responses.

Furthermore, as David's students learned, the STEM workforce is not always representative of a diverse student body. David asked his students to develop social media profiles for famous engineers to whom they could relate. Some of the students, specifically those of color, struggled to do so, and one ultimately developed a profile with a silhouette to recognize the lack of diversity in the field of engineering. In the USA, only 4.3% and 7.0% of all engineers self-identify as part of African American and Latinx populations, respectively (National Science Foundation & National Center for Science and Engineering Statistics, 2017). This student's personal crisis with the STEM workforce was an important realization for him to have as it led him to acknowledge the disparity in the field and aspire to change the national statistics. It is this disproportionate representation of Black and Latinx populations that scholars have cited as a vital reason for considering the cultural and linguistic background of students, and, therefore, provide culturally responsive instruction (Aguirre & del Rosario Zavala, 2013; Gutiérrez, 2009; Gutstein, 2006; Siwatu, 2011).

Although David's project did yield conversations about race and representation in STEM, absent from the CRP integration in all projects was a strong focus on social justice. Ladson-Billings (1994) defined CRP through three prominent tenets for instructional practices: (1) upholding high expectations for all students; (2) guiding students through the development of their cultural competence; and (3) fostering a sense of critical sociopolitical and cultural consciousness in students. The third outcome described by Ladson-Billings (1994) involves the development of critical consciousness which fosters the cultivation of an individual's sociopolitical awareness through cultural, social, and political engagement (Mustakova-Possardt, 1998). CRP empowers students to identify and tackle the injustices and inequities that impact their lives and represent the experiences of disenfranchised populations (Aguirre, 2009). Consequently, social justice has gained traction as an integral component of culturally responsive instruction, especially in the field of mathematics (Aguirre, 2009; Gutiérrez, 2009; Gutstein, 2006). The incorporation of CRP in mathematics concepts has shown to tackle a variety of topics ranging from the institutionalization of racism in mortgage lending practices (see Gutstein, 2006) to the use of quantitative analysis to challenge a school district's decision for closing a neighborhood school (see Varley-Gutiérrez, 2010). Consequently, for teachers to embody the aspect of CRP that encourages social justice, they must acknowledge that teaching their content is a political, rather than neutral, exercise (Aguirre & del Rosario Zavala, 2013).

Some of the projects designed by the participating teachers addressed social inequities in terms of access to resources and lack of diversity in the STEM workforce. Still, the sociopolitical consciousness was not directly evidenced in any of the projects. During the summer course and planning for the project, teachers were asked to align their projects with the eight dimensions of the culturally responsive mathematics and science teaching (CRM/ST) lesson analysis tool, originated by Aguirre and del Rosario Zavala (2013). The teachers all indicated that their projects met the cultural competence category which ensured the lesson utilized students' funds of knowledge, culture, and community support. Additionally, this competency manifested throughout the themes and meta-patterns identified in this research. Still, the use of critical knowledge to address social justice was lacking in the projects, and therefore not indicated on the teachers' alignment to the CRM/ST rubric. However, that is to be expected provided that this was the teachers' first year in the master's degree program and fellowship. Therefore, the projects were based upon their initial introductions to CRP, and representative of their first attempt at integration.

While the projects that teachers designed did not include social justice at this juncture, the concept of empathy was prevalent throughout student experiences and teacher self-reflections. Ashley's project allowed students to acknowledge that they lack access to warm meals unless purchased at their school. They developed prototypes for insulative-heaters which the students tested by self-utilization of food brought from home. Given that Ashley's school has no microwaves in the cafeteria, her students expressed that they were happy to have developed their protype. Students explained that, prior to doing so, many of them were consuming cold meals for lunch. In this case, the students were able to reflect upon how the topics in their science class can be used to provide access to resources for their community. Karen's students had a similar realization as they were given the option to develop a heavy load carrier for the librarian or the coaching staff. Students felt so motivated to help their selected recipient that many asked if they would ultimately scale their prototype to size to ensure that they could truly be of service. Additionally, Michelle shared that her students were deeply motivated by the concept of developing prosthetic models for veterans and others in need. She explained that her students researched additional disabilities, beyond those included in the assignment, and began brainstorming prototypes that would make life easier for those individuals.

This desire from the participating teachers to incorporate a sense of service in their students contributes towards the research offered by McAllister and Irvine (2002) on the role of empathy in CRP. An empathetic disposition on behalf of the teachers is a quality that researchers have associated with effective instructional practices especially in urban and diverse school settings (Darling-Hammond, 2000; Gordon, 1999). This quality allows individuals to foster sensitivity towards other cultures and approach situations by bearing others' perspectives and experiences in mind (Goleman, 1998). McAllister and Irvine (2002) further explained the impact of empathetic teachers in diverse classrooms by stating the following:

> Teachers are better able to modify pedagogy and curricula to fit their students' needs, such as the teacher who changed a classroom ritual to be more comfortable for her Vietnamese students by simply offering her students multiple ways to say goodbye rather than obliging them to hug her before they left the classroom. (p. 2002)

The participating teachers' willingness to promote these qualities in their students is a reflection in what they value within themselves. The teachers shared the need to utilize their students' funds of knowledge, experiences outside of school, and cultural backgrounds when designing curricula. Additionally, they expressed that they felt connected to their students, even those who were not engaged. The teachers reiterated throughout their interview and reflective journal entries their desire to spark students' interest and creativity in STEM-related topics. Hence, the teachers emphasized the need for culturally responsive instruction, not only for the students enrolled in advanced courses, but, even more so, for the students in their on-level or academic classes. The teachers advocated for these students in front of colleagues who felt the integration of CRP and the EDP would be better suited for high-performing students. Moreover, teachers stated that they felt inspired by the results from the project, which indicated not only improvement in academic performance but also involvement from students who otherwise remained on the sidelines of the classroom. Consequently, the findings from this research support the notion that the empathic disposition of teachers allows them to make efforts in utilizing their students' funds of knowledge (McAllister & Irvine, 2000). Furthermore, the findings suggest that emphatic teachers are likely to design and value instruction that fosters a sense of service in students.

## Contribution to the Field

This research is grounded in the assertion that it is of great significance to examine the ways in which teachers perceive and define new pedagogical approaches upon implementation. The insights provided by teachers have implications for how professional development providers and teacher educators present instructional practices to attain teacher buy-in. Moreover, the beliefs teachers hold about the pedagogical constructs will guide their curricular decisions. Therefore, the pursuit of teachers' endorsement is important because it determines the likelihood of teachers engaging in the novel practices. It is through investigation of the participating teachers' beliefs that the authors uncovered a vital pedagogical perspective that is indicative of how teachers will approach future implementations. The synergistic relationship between CRP and the EDP is discussed in this section and contributes to the literature in each field of practice.

### *The Culturally Responsive Engineering Design Process*

A key implication derived from this research is the connectivity between the EDP and CRP yielding a culturally responsive engineering design process (CREDP). A significant pattern and finding that emerged from this research is that upon enactment in unison, teachers perceived a powerful and natural relationship between the two pedagogical constructs. Moreover, an important aspect of this finding was that while teachers were able to conceive implementing CRP in the absence of the EDP, they were unable to do so in reverse. In other words, the value that teachers placed on implementing engineering design with a culturally responsive lens was so strong that they were unable to commit to or visualize the implementation of EDP without CRP. Teachers explained that through combined enactment they were able to reap the benefits of both constructs simultaneously.

Castaneda and Mejia (2018) have connected the three tenets of CRP as defined by Ladson-Billings (1994) with the standards established by the Accreditation Board for Engineering and Technology for a civil engineering program. Similarly, this research provides a framework that couples each of the three tenets of CRP with the iterative steps commonly found in prominent versions of EDP as used in K-12 curricula. See Table 9 (Massachusetts DOE, 2016).

### *CRP Tenet I*

Ladson-Billings (1994, 1995) described in her first tenet for CRP the importance of teachers adopting a mindset that expects all students to become academically successful. Ladson-Billings (2006) later clarified the term "academically successful" so to differentiate from student outcomes on high-stakes standardized tests, "What I envisioned is more accurately described as 'student learning' what is that students actually know and are able to do as a result of pedagogical interactions with skilled teachers" (p. 34).

As such, a teacher embodying CRP will need to approach students through an asset-based philosophy (Villegas & Lucas, 2002). This entails viewing students' cultural and linguistic background as an opportunity for involvement in content versus a characteristic that inhibits student potential. The practices in the EDP which include allowing students to identify the problem or need, research the problem, develop, test, and evaluate models for solution are all grounded in this tenet of CRP. It is important to note that the problem or need students are addressing must be framed around the students' cultural context. This was also identified as an important facet of their projects by all the participating teachers because it allowed for purposeful incorporation of CRP into the EDP. Moreover, providing students with the opportunity to design their own solution or prototype entrusts them with ownership over the problem and enables them to creatively address the problem (Householder & Hailey, 2012; Hynes, 2010). This was evidenced by the teachers' self-reported observations of their students' learning and engagement. Allowing students such experience naturally produces a student-centered classroom. However, it is this nature of the EDP, when employed with cultural relevance to students, that can meet the objectives of tenet I as described by Ladson-Billings (1994). Therefore, it is critical when connecting CRP with the EDP that the problem have a culturally responsive or relevant context.

Table 9
The EDP in relation to the three tenets of CRP.

| Steps in EDP | Tenets of CRP |
|---|---|
| Identify the problem | Tenet I: Upholding high expectations for all students<br>Tenet II: Guiding students through the development of their cultural competence<br>Tenet III: Fostering a sense of critical sociopolitical and cultural consciousness in students |
| Brainstorm and research the problem | Tenet I: Upholding high expectations for all students |
| Develop solutions | Tenet II: Guiding students through the development of their cultural competence |
| Create a protype | Tenet I: Upholding high expectations for all students |
| Test and collect data to evaluate design | Tenet I: Upholding high expectations for all students |
| Communicate the solution | Tenet II: Guiding students through the development of their cultural competence |
| Redesign | Tenet II: Guiding students through the development of their cultural competence |

### *CRP Tenet II*

According to Ladson-Billings (2006) the concept of fostering cultural competence in students is the most challenging component of CRP to convey to educators. Cultural competence does not necessarily mean cultural sensitivity, but rather, "helping students recognize and honor their own cultural beliefs and practices while acquiring access to the wider culture" (Ladson-Billings, 2006, p. 36). In other words, students are not only learning to be respectful of other cultures, but truly delving into the intricacies of cultures in a way that builds the conceptualization of their personal and collective cultures. This tenet is associated with students designing solutions to solve a problem or need that is steeped in culturally relevant context. Accordingly, to develop prototypes, conduct data analysis, and communicate solutions, students must be immersed in understanding the cultural and/or linguistic context associated with the project. Providing students with the opportunity to engage in these steps allows for the inclusion of tenet II into the EDP.

### *CRP Tenet III*

Tenet III involves sociocultural and political consciousness. This area of CRP was the least evidenced in the teachers' projects and is often less likely to appear in projects designed by teachers who are not well-versed or comfortable with CRP (Gay & Howard, 2000; Young, 2010). Additionally, teachers often struggle with this concept of CRP because they are lacking in their own sociopolitical consciousness (Gay & Howard, 2000). Still, should a teacher be willing to infuse this tenet in their instruction, the EDP can be operationalized by solving a problem that is not only relevant and capable of fostering cultural competence but also charged with addressing inequities and injustices in social, cultural, and political settings. For example, in the culturally responsive mathematics assignment shared by Varley-Gutiérrez (2010), students use data analysis to challenge a school district's decision to shut down a neighborhood school due to budgetary concerns. A potential extension through incorporation of EDP for the same problem might include developing prototypes or blueprints for modifications to the school that can result in efficiency and save the district money.

Teacher participants, having implemented the two constructs simultaneously through classroom projects, were convinced that engineering design was most beneficial and worthwhile to use when it is immersed in their students' cultural context. All participating teachers acknowledged the value of each construct and were willing to embody CRP on its own, and as a pivotal facet impacting instructional and curricular decisions. Nevertheless, based upon the positive outcomes experienced through the synergistic enactment of CRP and EDP, the teachers felt compelled to frame each engineering design challenge around a problem that was culturally responsive towards their students. Based on the findings from this study, formalizing the relationship between the two constructs and adopting a CREDP have the potential to yield greater teacher buy-in which is essential for all curricular reform efforts (Cheng & Huang, 2018).

### *Recommendations for Stakeholders*

The findings from this research offer valuable recommendations for teacher educators, professional development providers, and researchers. The research, while premised around CRP and the EDP, examined beliefs and agentic behaviors of teachers. The participating teachers are part of a master's program and fellowship designed to promote teacher leadership and cultivate teachers' pedagogical content knowledge around CRP and other innovative instructional approaches. Thusly, the teachers', prior to their integration of CRP and the EDP, already displayed signs of agency and motivation to improve their own instruction and impact the practices of others.

The authors of this research recognize that examining beliefs and agentic behaviors is a complex process which is dependent upon self-reported data (McAllister & Irvine, 2000, 2002). To further clarify the intentionality of the authors, this research does not purport to draw any relationships between the teachers' experiences in the fellowship to their self-reported beliefs and instructional outcomes. The research instead seeks to understand the reactions teachers have to the pedagogical constructs of CRP and the EDP upon implementation. The study examines how teachers define each construct after the experience, the value they associate with approaches, and how those beliefs relate to their agency regarding continued implementation. Below are recommendations that emerged from the findings and should be of interest and value to stakeholders in the field of teacher education.

### *Recommendations for Future Research*

The crux of this research lies in valuing the beliefs and insights of teachers because they are the most critical component to any change in instructional practice. Much research has been conducted on exploring the value of each of the two pedagogical constructs, the EDP and CRP. Some of these studies have involved teachers' beliefs (see Siwatu, 2007; Yaşar et al., 2006; Yoon et al., 2018). Nevertheless, there remains a shortage of research on investigating how teachers respond to the instructional practices upon enactment in their classes. This is problematic because beliefs and attitudes are dynamic and evolve through observations and experiences (Bandura, 1986). Therefore, the beliefs teachers have during their preservice years, or upon introduction to an approach, are not entirely representative of how teachers will describe the value of the instructional practices upon attempting them with their students. Moreover, examining these beliefs allows for the researcher to gain insights on which aspects of the pedagogical approaches are most appealing to teachers and which challenge them. Thus, the concepts that excite teachers can help researchers uncover strategies for introducing novel instructional practices. Accordingly, addressing the areas that cause hesitation in teachers can help strengthen the reform through targeted support.

## Conclusions

Much like any instructional or pedagogical intervention, the teachers' buy-in and beliefs surrounding the approaches will determine the fidelity with which the constructs are implemented. This research provided insights on how teachers, who are motivated to enact change, perceived the constructs of the EDP and CRP upon implementation. The teachers had no prior experience with the pedagogical approaches before entering the program. Moreover, since their introductory coursework on the topics, this iteration was their first time in adopting instruction inclusive of CRP and EDP. The insights and statements captured during this research are reflective of their initial reactions to the implementation. The authors of this research acknowledge that the teacher participants' beliefs will likely evolve as they progress through the coursework and professional development. However, first impressions are of significance because experiences and observations have the power to influence agency towards future enactments. Additionally, the barriers these teachers encountered along the way and how they self-reacted to persevere through those challenges are also of importance. The findings can serve as lessons that will help strengthen the development of other teachers who are not as confident in their instructional abilities, or comfortable with parting from teacher-centered practices.

Another key implication derived from this research is the connectivity between the EDP and CRP. Specifically, teacher participants, having experienced the two constructs simultaneously, were convinced that the EDP was most beneficial and worthwhile to use when it is immersed in their students' cultural context. The teachers acknowledged the value of each approach and shared their willingness to use CRP on its own. However, based upon the outcomes experienced through the synergistic enactment of the EDP and CRP, the teachers felt compelled to frame each engineering design challenge around a problem that was culturally responsive towards their students. Provided the power of teacher buy-in, this finding is of critical importance to teacher educators in the fields of teacher development, STEM education, engineering education, and CRP.

Finally, professional development providers and policy makers are urged to place teachers at the forefront of any conversation that is charged with producing reform. Researchers are advised to examine the ways in which teachers perceive, react to, and define instructional approaches that are deemed impactful. Involving willing teachers as active contributors to the field, as opposed to passive recipients of instructional initiatives, can help cultivate teachers' change agency. Accordingly, this research underscores the importance of empowering teachers with professional development that is shaped and informed by their beliefs and experiences. It is imperative to acknowledge and foster the power of teacher change agents who if given the opportunity will transform traditionalistic approaches throughout our educational system.

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