

# Journal of Pre-College Engineering Education Research (J-PEER)

---

Volume 10 | Issue 1

Article 1

---

2020

## Recognition and Positional Identity in an Elementary Professional Learning Community: A Case Study

Christopher G. Wright  
Drexel University, [cgw57@drexel.edu](mailto:cgw57@drexel.edu)

Rasheda Likely  
Drexel University, [RSL67@drexel.edu](mailto:RSL67@drexel.edu)

Kristen B. Wendell  
Tufts University, [kristen.wendell@tufts.edu](mailto:kristen.wendell@tufts.edu)

*See next page for additional authors*

Follow this and additional works at: <https://docs.lib.purdue.edu/jpeer>



Part of the [Elementary Education Commons](#), and the [Elementary Education and Teaching Commons](#)

---

### Recommended Citation

Wright, C. G., Likely, R., Wendell, K. B., Paugh, P. P., & Smith, E. (2019). Recognition and Positional Identity in an Elementary Professional Learning Community: A Case Study. *Journal of Pre-College Engineering Education Research (J-PEER)*, 10(1), Article 1.  
<https://doi.org/10.7771/2157-9288.1214>

This document has been made available through Purdue e-Pubs, a service of the Purdue University Libraries. Please contact [epubs@purdue.edu](mailto:epubs@purdue.edu) for additional information.

This is an Open Access journal. This means that it uses a funding model that does not charge readers or their institutions for access. Readers may freely read, download, copy, distribute, print, search, or link to the full texts of articles. This journal is covered under the [CC BY-NC-ND license](#).

---

# Recognition and Positional Identity in an Elementary Professional Learning Community: A Case Study

## Abstract

Professional learning communities are typically conceived of as spaces for reducing teacher isolation, supporting informed and committed teachers, and fostering student academic gains. Focusing on a professional learning community that supported the teaching and learning of engineering in elementary schools, we also conceived of this learning environment as a space for negotiating a teacher-of-engineering identity. Calling attention to emergent issues of power and status through a lens of positional identity, this article examines a Black female educator's sense of self as a teacher-of-engineering and how this perception was informed by participation in the professional learning community. Findings reveal that racialized and gendered positionings informed the teacher's perception of having limited access to being recognized in this space as a teacher-of-engineering. Implications for this work include reimagining the design of professional learning spaces in engineering education that intentionally account for teachers' identity development, as well as supporting the identity development for teachers from historically marginalized communities.

## Keywords

positional identity, elementary engineering, teacher education

## Document Type

Article

## Authors

Christopher G. Wright, Rasheda Likely, Kristen B. Wendell, Patricia P. Paugh, and Elizabeth Smith



Journal of Pre-College Engineering Education Research 10:1 (2020) 1–12

## Recognition and Positional Identity in an Elementary Professional Learning Community: A Case Study

Christopher G. Wright,<sup>1</sup> Rasheda Likely,<sup>1</sup> Kristen B. Wendell,<sup>2</sup> Patricia P. Paugh,<sup>3</sup>  
and Elizabeth Smith<sup>4</sup>

<sup>1</sup>Drexel University

<sup>2</sup>Tufts University

<sup>3</sup>University of Massachusetts - Boston

<sup>4</sup>Knox County Public Schools

---

### Abstract

Professional learning communities are typically conceived of as spaces for reducing teacher isolation, supporting informed and committed teachers, and fostering student academic gains. Focusing on a professional learning community that supported the teaching and learning of engineering in elementary schools, we also conceived of this learning environment as a space for negotiating a teacher-of-engineering identity. Calling attention to emergent issues of power and status through a lens of positional identity, this article examines a Black female educator's sense of self as a teacher-of-engineering and how this perception was informed by participation in the professional learning community. Findings reveal that racialized and gendered positionings informed the teacher's perception of having limited access to being recognized in this space as a teacher-of-engineering. Implications for this work include reimagining the design of professional learning spaces in engineering education that intentionally account for teachers' identity development, as well as supporting the identity development for teachers from historically marginalized communities.

*Keywords:* positional identity, elementary engineering, teacher education

---

*“In fact, several times in the years I have been at the school, it [the school] was up to be closed down because it [the school] was too small, the kids don't learn anything, and it was pointless to stay open.”*

Ms. Eboni Scott<sup>1</sup>

### Introduction

The case study presented in this article details a teacher's experiences with negotiating a teacher-of-engineering identity while participating in a professional learning community (PLC). Borrowing from and building upon Luehmann's (2007) notion of teacher professional identity, we conceptualized a teacher-of-engineering identity as being recognized by self and/or others as displaying competencies for the teaching and learning of engineering. Accordingly, this research focused on

---

<sup>1</sup>For the privacy of participating schools, teachers, and students, pseudonyms are utilized throughout the article.

understanding Ms. Scott's sense of self as a teacher-of-engineering, and how the construct of *recognition* functioned to influence her perception of having limited access to this identity. Ms. Scott, a self-identified Black female educator within a predominantly Black school, was asked to reflect on her visible discomfort with verbally engaging in PLC discussions. As seen in the above quote, she revealed a perception that her opinions and/or insights would not be valued within the learning setting due to the deficit reputation of her school and students within the school district. This response calls attention to what Carlone (2012) acknowledged as the dialectic nature of identity, where "people have a say in who they become (agency), [however] that agency is often limited by historical, social, institutional, and local structures" (p. 11). Acknowledging this dialectic aspect of identity and the potential for professional learning settings to afford or constrain one's access to a teacher-of-engineering identity, we deployed a positional identity framework as a lens for examining the complexities in Ms. Scott's sense of self as a teacher-of-engineering.

Understanding Ms. Scott's perceptions of her access to a teacher-of-engineering identity is particularly pertinent as the engineering education community continues to grapple with issues pertaining to K-12 teacher diversity. Diaz, Cox, and Adams (2013) argued, "similar to efforts in engineering to increase the representation of underrepresented groups in science and engineering, efforts to increase the representation of minority teachers with interests in DET (design, engineering, & technology) are needed in elementary classrooms" (p. 19). While the issue of shortages of teachers from historically marginalized communities is not unique to the engineering education community, foregrounding this pervasive and under-examined problem of teacher diversity would serve as a major contribution to the field's ongoing efforts in addressing equity and diversity concerns (Valla & Williams, 2012). We suggest that the development of approaches for understanding experiences and positionality of teachers like Ms. Scott could potentially inform the ways in which teacher educators approach the design of future professional learning environments, where the personal histories and positionality of teachers from historically marginalized communities are considered.

### **Focusing on Teacher-of-Engineering Identity in Teacher Education**

Despite the increase in research focusing on the support of elementary teachers' facilitation of engineering design activities (Capobianco, DeLisi, & Radloff, 2018; Johnson, Wendell, & Watkins, 2017; King & English, 2016; Watkins et al., 2018), research dedicated to the development of teacher professional identities, especially those from historically marginalized communities, has yet to be extensively examined within engineering education. Previous research on models of professional learning within engineering education has mainly focused on the development of teachers' pedagogical content knowledge and understandings of engineering (Duncan, Diefes-Dux, & Gentry, 2011; Hsu, Cardella, & Purzer, 2010; Sun & Strobel, 2014; Yoon, Kong, Diefes-Dux, & Strobel, 2018), as well as on changes in teachers' attitudes towards engineering (Hsu, Purzer, & Cardella, 2011; Yoon, Diefes-Dux, & Strobel, 2013). These lines of research provide invaluable insights into ways of supporting elementary teachers' pedagogical approaches for teaching engineering. Alternatively, other scholars suggest that the process of becoming a particular kind of teacher (e.g., elementary school teacher-of-engineering or reform-minded science teacher) "involves much more than acquiring a new set of knowledge and skills" (Luehmann, 2007, p. 823). Specific to engineering education, Lottero-Perdue (2013) asserted, "those interested in engaging elementary children in high-quality engineering education...must also be concerned with ways in which elementary teachers develop identities as teachers-of-engineering" (p. 27). As such, in this article, we build upon the work of other scholars that emphasizes developing teachers' pedagogical approaches for teaching engineering and argue for the importance of research that is just as concerned with teachers' "transformation of identity" (Deneroff, 2016, p. 230) or the development of a teacher-of-engineering identity.

Drawing attention to the importance of understanding how social positioning can frame identity development in teacher education, we examined how Ms. Scott's positional identity within the PLC was instrumental in her sense of self as a teacher-of-engineering. The following section situates the current research within the literature on professional models of learning and the complexities associated with negotiating teacher identities within science education. Next, the construct of recognition within a framework of positional identity will be introduced and discussed as the study's theoretical framework. After elaborating on the framework, the study's methods are provided, including a detailed description of the PLC and individual teacher case, and specific approaches for data collection and analysis. Then, analysis of the positional markers that framed Ms. Scott's perceptions of the potential for not being recognized as a teacher-of-engineering within the PLC will be unpacked. Finally, implications for attending to positional identity, particularly the identities of teachers from and/or who teach in historically marginalized communities, within models of professional learning in engineering education will be proposed.

### **Professional Learning as Identity Negotiation: Becoming a Reform-Minded Science Teacher**

Due to engineering education's scant history of examining teacher professional identities, this section synthesizes literature within science education that explored the complexities associated with negotiating reform-minded science teacher

identities. Performing as a reform-minded science teacher calls for enacting pedagogical practices that privilege students' engagement in scientific inquiry (Avraamidou, 2014), which is similar to students' engagement in an engineering design process. Much of the research that has detailed processes of constructing a reform-minded science teacher identity brings attention to the uncertainty that teachers associated with being recognized for implementing aspects of scientific inquiry, especially when the pedagogical approaches go against the norms and expectations of science instruction (Luehmann, 2008; Settlage, Southerland, Smith, & Ceglie, 2009). Research has focused on identifying these perceived uncertainties and applying these findings in the design of teacher learning environments.

Research has acknowledged that teachers' uncertainties with trying out new identities with teaching science were commonly informed by teachers' previous experiences with the subject matter, the context of the social environment in the learning space, resources within the learning environment, and previously maintained identities. For instance, research has detailed how professional learning experiences have been informed by the knowledge that the negotiation of reform-minded science teacher identities could be influenced by teachers' previous experiences (Akerson, Carter, & Elcan, 2016) and personal histories (Danielsson & Warwick, 2014) with science and science instruction. Designing learning environments that attend to these particular kinds of issues requires the field's understanding of the potential risks that teachers associate with trying out new identities. Saka, Southerland, Kittleson, and Hunter (2013) pointed out the need for developing supports for teachers who try out reform-minded science teacher identities within school environments where the associated pedagogical practices conflict with the school's goals and expectations for engaging students in science. Collectively, these studies call for additional research that explores teacher professional identities through a lens of perceived risks, as professional learning environments consider opportunities for supporting the negotiation of new teacher identities.

Focused on the construct of recognition, Luehmann (2007) acknowledged that "trying out and considering a new identity means inviting others to recognize you for your ability to participate in a discourse that is new to you—and thus opens you up to the possibility of not being recognized as such" (p. 831). Informed by historical exemplars of racial and/or gender inequalities for being recognized within educational spaces (Bristol, 2018; Goings, 2015; Mensah, 2019; Milner, 2012; Tillman, 2004), the foundational premise of our research is that the potential risks or uncertainties with trying out new professional identities are heightened when considering teachers from historically marginalized communities. Specifically, previous research has noted how Black teachers have been historically subjected to racialized perceptions of themselves or the students they serve when being recognized or acknowledged as particular kinds of teachers (Bristol & Goings, 2019; Bristol & Mentor, 2018; Mensah & Jackson, 2018). Following Nasir (2012), we utilized the term racialized to communicate that "race is not an inherent category, but experiences are made racial through social interaction, positioning, and discourse" (p. 5) for Black teachers and students within educational spaces. Specific to science education, Upadhyay (2009) detailed the perceived uncertainties that a Black female teacher associated with her engagement in the pedagogical practices connected to reform-based science instruction. For this teacher, engaging in these pedagogical practices was counter to her school's emphasis on test preparation for her Black and Brown students. Thus, enacting a reform-minded science teacher identity ran the risk of her Black and Brown students not "succeeding" on statewide assessments, consequently reducing the possibilities for being recognized as a science teacher within her specific setting.

The previously discussed literature speaks to the need for continued research that examines what it means to be recognized as a particular kind of teacher in various contexts, as well as what would it mean to provide teachers with opportunities for engaging in what Luehmann (2007) refers to as ongoing "recognition work" (p. 833). Previous models of K-5 professional learning in engineering education have primarily focused on developing elementary school teachers' knowledge base and understanding of engineering, while overlooking opportunities for also supporting the negotiation of teacher-of-engineering identities (Lottero-Perdue, 2013). Through this case study, we look to contribute to the literature on the negotiation of teacher-of-engineering identities by situating this research in a framework of *positional identity*, and explore the positional markers that a Black female elementary school teacher identified as potential limitations in being recognized a teacher-of-engineering within a PLC.

### **Positional Identity as a Lens for Exploring Ms. Scott's Teacher-of-Engineering Identity**

Foregrounding Ms. Scott's sense of self as a teacher-of-engineering while participating in a PLC, we utilized a positional identity framework. Holland, Lachicotte, Skinner, and Cain (1998) defined positional identity as "how one identifies their position relative to others, mediated through the ways that one feels comfortable or constrained" (p. 127). Hence, the use of positional identity within this study acknowledged Ms. Scott's agency in her sense of self, while also recognizing that her sense of self was framed and influenced by perceived "situational and historical constraints" (Mensah, 2012, p. 105) associated with participating in the PLC. Ms. Scott's conceptualization of her teacher-of-engineering identity was not a settled or fixed notion. Rather, it highlighted the social negotiation of her positionality in relation to others within the PLC. Scholars, such as Maulucci (2013) and Mensah (2016), contend that a positional identity framework is particularly useful for capturing

the complexities and dynamic nature of authoring identities when involving teachers of color because it calls for unpacking dimensions of power and access within teacher education. Specifically, positional identity foregrounds an intersectional (Collins & Bilge, 2016; Lewis, Mendenhall, Harwood, & Hunt, 2016; Powers & Duffy, 2016) understanding of how teachers' social positionings (Holland & Leander, 2004) such as race, class, gender, and age simultaneously frame their sense of self and positionality within social contexts.

### *Situating the Construct of Recognition within a Positional Identity Framework*

The research presented in this article conceptualized a teacher-of-engineering identity as being recognized by self and/or others for displaying the competencies for the teaching and learning of engineering. This conceptualization highlights the notion of *recognition* and its potential influence in framing Ms. Scott's sense of self as a teacher-of-engineering within the PLC. Situating recognition within this framework contextualized the "sociocultural, sociohistorical, and sociopolitical dimensions" (Mensah, 2012, p. 106) of the PLC that Ms. Scott called upon in considering how she might be recognized, or not, as a teacher-of-engineering. This notion of "recognition messages" (Godwin, Potvin, Hazari, & Lock, 2016, p. 316) or the perceptions of how others in a particular context view an individual have been found to be essential elements in the ways that individuals view themselves in context (Carlone, 2012; Carlone & Johnson, 2007; Tonso, 2006). Thus, the construct of recognition emerged as a critical element in exploring Ms. Scott's sense of self as teacher-of-engineering and positionality within the PLC.

Congruous with Mensah's (2012) use within science education, we utilized positional identity as an analytic lens for unpacking Ms. Scott's sense of self as a teacher-of-engineering. Here, positional identity was conceptualized through the intersections of the various social positionings Ms. Scott called upon while formulating her perception of having access to a teacher-of-engineering identity within the PLC. Specifically, positional identity framework was utilized to examine and analyze Ms. Scott's conversations about her sense of place within the PLC. The research question that guides this research is: *in what ways did issues of power and status within the PLC frame Ms. Scott's perceptions of having access to a teacher-of-engineering identity?*

## **Methods**

The case study presented in this article took place within a larger research project that developed and studied effective pedagogical approaches for supporting elementary students' use of reflective decision-making while engaged in engineering design activities. Reflective decision-making was envisioned as a combination of two disciplinary practices within the Next Generation Science Standards (NGSS Lead States, 2013): (a) designing solutions and (b) engaging in argument from evidence (Wendell, Wright, & Paugh, 2017). The PLC was designed to support teachers' cultivation of this practice within their respective classrooms.

### *Context of the Study: The Engineering PLC*

Deploying a framework of positional identity necessitates an understanding of the context within which an individual is framing their positionality. Thus, in this section we provide a rich description of the PLC and what it meant to display competencies for the teaching and learning of engineering. The PLC consisted of two Black female teachers at Septima Clark Elementary School, two White female teachers from Dorothy Height STEM Magnet School, and a university engineering education researcher (a Black male professor from the local university). Septima Clark Elementary and Dorothy Height STEM Magnet were two different public schools in the town of Dickerson, a town located in the southeastern region of the United States. Both Septima Clark and Dorothy Height were located on the "eastside" of Dickerson, also recognized as the "Black part of town," as opposed to the "westside" that contained a larger number of affluent White families and students. Although Dorothy Height Magnet was located on the eastside of Dickerson, there was a perception within the town that the student demographics would be changing due its new reconstitution as a STEM magnet school and the increased resources provided to the school.

Professional learning sessions were held once or twice per month depending on holidays and weather-related school conditions, and the location of the sessions alternated between the two schools. Being a teacher-of-engineering within the PLC meant providing data from teachers' respective classrooms that exemplified students' participation in engineering design activities and the practice of reflective decision-making. Data primarily included student pre- and post-assessments, classroom video and transcripts of student design teams engaged in design work (see Figure 1), and/or students' design solutions and/or other artifacts (see Figure 2). In addition, displaying competencies for teaching and learning in engineering also included actively participating in PLC discussions regarding the analysis of students' engagement in reflective decision-making.



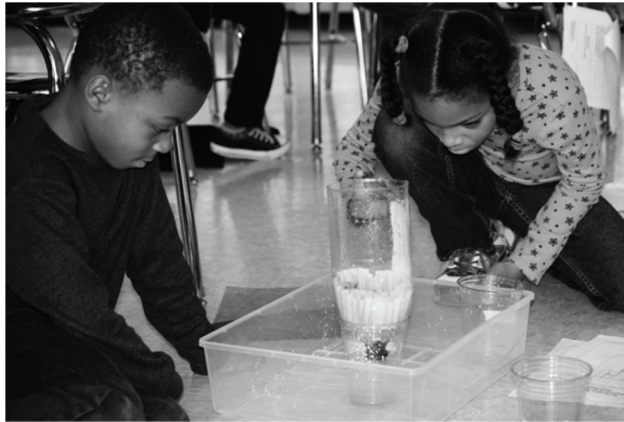


Figure 1. Image from video data depicting student design team interaction.

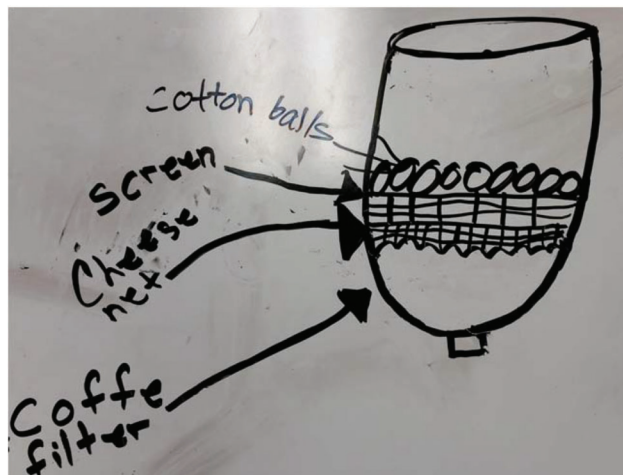


Figure 2. Image of a design team's drawing for their design solution.

This space of sharing and collectively analyzing student work was conceptualized as an essential component in supporting teachers' competencies for recognizing students' participation in various discursive practices, thus a space for negotiating a teacher-of-engineering identity. Individual case studies were developed for each of the four participating teachers; however, Ms. Scott's case emerged as presenting a unique opportunity for understanding and explicitly considering how social positionings, such as race, class, age, and gender, informed her sense of self as a teacher-of-engineering.

#### *Who Is Ms. Scott?*

Ms. Scott was a self-identified Black female elementary school educator who was one of Septima Clark Elementary School's most tenured teachers, having served the school for approximately 10 years at the time of the study. Septima Clark Elementary was a small, public school located in the predominantly Black community of Sunnyside with approximately 250 students in grades kindergarten through fifth. The school's student population included 67% Black, 21% White, 6% biracial, and 5% Latinx, and 76% of students received free or reduced lunch. While conversing about teaching at Septima Clark Elementary, Ms. Scott would often reference the historical significance of the school, as well as the Sunnyside community, in providing access to quality education for the town's Black community. Specifically, Ms. Scott's stories typically included Septima Clark's status as a pillar of the community. Despite its historical significance in Dickerson, and particularly the Sunnyside community, Septima Clark Elementary was consistently threatened by the potential dissipation of the school due to low student outcomes on state standardized testing and declining enrollment. Although Ms. Scott was not a Sunnyside resident, she took great pride in being able to contribute to the community's prosperity through various religious, community, and educational efforts. At the time of the study, Ms. Scott did not have any prior experiences with teaching engineering. In fact, Ms. Scott often communicated as having a history of adverse participation with teaching anything that could be

categorized as being “science-related.” Ms. Scott’s inclusion in this research project was through the recommendation of Septima Clark’s newly appointed Black male principal, who Ms. Scott considered as a well-respected professional mentor.

### Data Collection

A qualitative case study methodology was used for this study (Merriam & Tisdell, 2016). This approach called for an in-depth description and analysis of a bounded system (Creswell, 2007), which was conceptualized as Ms. Scott’s perceptions of being recognized as a teacher-of-engineering within the PLC. A case study approach is described as an “empirical inquiry that investigates a contemporary phenomenon within a real-life context” (Yin, 2003, p. 13). In the current study, we maintained that Ms. Scott’s sense of self and positionality within the “real-life context” of the PLC influenced her negotiation of a teacher-of-engineering identity.

Several data sources were collected and analyzed over a nine-month period in order to present the case of Ms. Scott. We depended on a combination of semi-structured interviews, memos detailing conversations with Ms. Scott, email correspondences, and field notes taken during Ms. Scott’s facilitation of engineering lessons at Septima Clark Elementary and participation in the PLC. Semi-structured interviews were conducted at the beginning, middle, and end of the nine-month period, for a total of three interviews. Interviews were designed to provide Ms. Scott with opportunities to discuss her views on her preparation for and facilitation of engineering design lessons at Septima Clark Elementary, discuss future implementations of engineering design activities, and reflect on her positionality within the PLC. Additional data were collected through field notes detailing observations made during Ms. Scott’s facilitation of engineering design lessons at Septima Clark Elementary and participation in the PLC. Field notes generally focused on Ms. Scott’s interactions with her students and/or teacher peers, and specific communications within these settings. Data derived from field notes were subsequently utilized to inform the research team’s interactions and inquiries of Ms. Scott during conversations and email correspondences. These data allowed us to gain insights into how Ms. Scott viewed herself within the PLC and how she experienced others’ perceptions of her as a teacher-of-engineering.

### Data Analysis

Interviews, as well as written data (e.g., memos, email correspondences, and field notes), were transcribed and coded using methods of grounded theory (Charmaz, 2006). Coding originated with an attentive reading of data in order to develop a general understanding of the data. Sticking closely to the data, an initial analysis allowed for the emergence of preliminary codes that detailed the social positionings that Ms. Scott called upon while discussing her thoughts on becoming a teacher-of-engineering (see Table 1). This analysis was essential in preparing for a process of focused coding, where codes were identified within conversations where Ms. Scott specifically discussed being recognized as a teacher-of-engineering within the PLC. This process allowed for the identification of social positionings that Ms. Scott associated with being recognized, or not. To further validate the analysis of Ms. Scott’s perceptions, the research team utilized the technique of member checking (Creswell & Miller, 2000), which involved getting Ms. Scott’s sentiments on the interpretation of her experiences within the PLC. This process generated additional insights into Ms. Scott’s sense of self as a teacher-of-engineering within the PLC and fostered further refinement of the emergent themes.

Table 1

Social positioning codes emerging from analysis of Ms. Scott’s interviews and conversations.

Social positioning	Description of the positioning	Example excerpt from the data
Class references	References made about the class status of Ms. Scott, teacher peers, and/or engineers, in general	“In my mind, engineers were White men <b>with money</b> . Period.”
Experiences of teaching engineering	References to teaching experience with teaching engineering for Ms. Scott or teacher peers	“In my mind, I am too old to learn anything new, and this <b>engineering stuff is new</b> to me.”
Gender references	Reference to gender identification for Ms. Scott, teacher peers, and/or engineers	“I have never seen a Black engineer, or <b>a female</b> for that matter.”
Personal histories with science and/or engineering	References to prior histories and/or experiences with engineering and/or science	“I am <b>already not a fan of science</b> , so I am not jumping for joy at engineering.”
Racialized references	References to racial identification of Ms. Scott, teacher peers, and/or engineers	“In my mind, engineers were <b>White men</b> with money.”
Teacher of Black students	References to being a teacher at Septima Clark Elementary, Ms. Scott’s role as a Septima Clark teacher, and/or general perceptions of Septima Clark and students	“Septima Clark is an inner-city school with <b>majority Black students</b> ...The reputation of Septima Clark is that it is a school for students who don’t want to learn anyway.”



## Findings

An analysis of conversations (i.e., interviews, email correspondences) with Ms. Scott revealed how her perceptions of her social positionings within the PLC influenced her sense of self as a teacher-of-engineering. Specifically, three social positionings emerged to influence Ms. Scott's perception of being recognized as a teacher-of-engineering and included: (a) the perceived lack of STEM experiences when compared with her peers within the PLC, (b) being a teacher of a predominantly Black student population at Septima Clark Elementary, and (c) being a Black, female teacher within Dickerson, a town in the Deep South region of the United States. The following sections detail each of these themes and explore how each contributed to Ms. Scott's framing of having limited access to a teacher-of-engineering identity within the PLC.

### *Ms. Scott's Perception of Lacking Previous STEM Experiences*

When discussing her reluctance for offering pedagogical suggestions for supporting students' engagement in reflective decision-making within the PLC, Ms. Scott stressed her lack of experience with teaching engineering as presenting a potential barrier for being recognized as a legitimate teacher-of-engineering. Specifically, Ms. Scott juxtaposed her lack of experiences with teaching STEM with her perceptions that teachers from Dorothy Height STEM Magnet were more experienced and qualified to provide suggestions. For instance, during an interview approximately two months into the project, Ms. Scott noted:

*My perception is that most schools are named for what they do best. Since Dorothy Height is a STEM school, the thought is that they are already proficient in this [teaching engineering] than we [teachers from Septima Clark Elementary] are. Septima Clark is not a magnet anything; it is merely a school in a historic part of town.*

Analysis of Ms. Scott's response called attention to how her social positioning within the PLC was informed by commonly held assumptions regarding STEM schools, where "STEM labels" extend privileges to specific schools, teachers, and students. Subotnik, Tai, Rickoff and Almarode (2009) suggested that STEM schools are commonly viewed as the "crown jewels" (p. 7) of their respective school districts and assumed to attract the most talented teachers and students. The increase of resources (e.g., STEM curricula, professional development, technology) provided to Dorothy Height was a well-known fact throughout the town of Dickerson. Thus, Ms. Scott viewed her lack of experience with teaching engineering as an impediment for being recognized as a teacher-of-engineering within the PLC, where "teachers who were more proficient" at teaching engineering would not acknowledge her as a legitimate teacher-of-engineering. The irony in Ms. Scott's perceptions was that Dorothy Height STEM Magnet was a newly constituted STEM school and the teachers' experiences with teaching engineering were similar to those of Ms. Scott. However, in this particular context, the social status typically afforded to schools designated as STEM schools, such as Dorothy Height, served as a social positioning that magnified Ms. Scott's lack of experience within the PLC. Thus, Ms. Scott's perceived lack of experience with teaching engineering, in relation to the teachers from Dorothy Height, contributed to her framing of having limited access to a teacher-of-engineering identity.

### *Being a Teacher of a Predominantly Black Student Population at Septima Clark Elementary*

In addition to her limited experiences with teaching engineering, Ms. Scott also acknowledged how the intersection of racialized and classed stereotypes associated with Septima Clark limited her access to being recognized as a teacher-of-engineering within the PLC. Specifically, during a conversation following one of the professional learning sessions, Ms. Scott articulated her perceptions of how Septima Clark was positioned within the Dickerson School District as she stated:

*Septima Clark is an inner-city school with majority Black students. It does not have the luxuries of other schools, including hot water, access to technology (i.e., iPads 3D printers), and dependable heat that works. The reputation of Septima Clark is that it is a school for students who don't want to learn anyway.*

Here, Ms. Scott provided a foundational understanding of the ways in which Septima Clark Elementary was perceived throughout Dickerson, and the likelihood for other teachers within the PLC to hold these assumptions. Ms. Scott's perceptions of Septima Clark's racialized (i.e., majority Black students) and classed (i.e., inner-city school) positioning within Dickerson were informed by her sociohistorical understanding of the lack of care, attention, and funding typically denied to schools with these student demographics (Pinkney, 2016; Vaught, 2009). This response provided a foundation for Ms. Scott's understanding of how being a teacher at Septima Clark, a school with a predominantly inner-city Black student population,

could potentially limit her access for being recognized as a teacher-of-engineering within the PLC. Speaking of how her understanding of Septima Clark's positioning within Dickerson informed her positionality within the PLC, Ms. Scott stated:

*No one [in the Dickerson School District] cares about Septima Clark because of its demographics and location [Sunnyside community]. Those [teachers from Septima Clark] who have tried to go elsewhere had a hard time because they [teachers from Septima Clark] taught here and know nothing. So, the thought of a teacher from that school [emphasis added] doing something that requires critical thinking and intelligence is unheard of.*

In this response, Ms. Scott acknowledged how being a teacher at Septima Clark could restrict her access to being recognized as a good teacher, let alone being recognized as a teacher-of-engineering. Specifically, Ms. Scott maintained a view of teaching and learning in engineering that requires a specific level of critical thinking and intelligence, two qualities typically not afforded to Septima Clark teachers and students. Consequently, Ms. Scott's awareness of Septima Clark's reputation within the Dickerson School District contributed to her sense of self as having limited access to being recognized as a teacher-of-engineering.

#### *Being a Black Female Educator Within Dickerson*

The lack of accessibility that Ms. Scott associated with being recognized as a teacher-of-engineering within the PLC was also informed by her previous experiences with and understanding of gendered racism, forms of discrimination due to the intersection of race and gender (Szymanski & Lewis, 2016; Thomas, Witherspoon, & Speight, 2008), within the Dickerson School District. Following a professional learning session, Ms. Scott was asked about an observation of her "quietness" during the analysis of video data where participating teachers were collectively identifying moments in which students from Dorothy Height were engaging in design activities. Ms. Scott responded:

*"You do realize that we're in the Deep South, right? You do realize that in typical professional development settings that the opinion of a Black woman doesn't carry as much weight as those from a White teacher? Yes, even adults have rejection problems, also, and I felt that you [the university researcher] just had pity for us and trying to help us along.*

Ms. Scott's initial questioning of the university researcher (e.g., you do realize that we're in the Deep South, right) and the subsequent follow-up emphasized her expectation of being denied access to a teacher-of-engineering identity within the professional learning setting due to the intersection of being a Black female educator in this context. Specifically, Ms. Scott demonstrated a sociohistorical awareness of the experiences of Black educators within the "Deep South" (Fairclough, 2009) and a sociocultural understanding of how being a Black female teacher in Dickerson aligned with previous findings where Black female teachers have been historically silenced and marginalized in educational settings (hooks, 1994). Ms. Scott's response also forced the Black male university researcher to examine his positionality within the PLC (Milner, 2007). Despite sharing a racialized identity with the university researcher, Ms. Scott acknowledged that she initially viewed him as a representative of the local university, which had a reputation for not collaborating with schools, students, and teachers in Sunnyside due to the racialized and classed stereotypes of the community. Thus, Ms. Scott's perception of potentially being denied recognition as a teacher-of-engineering extended to the university researcher, as exemplified in her statement, *"I felt that you just had pity for us [Septima Clark teachers]."*

#### **Discussion**

The case study presented in this article looked to call attention to the importance of attending to teachers' negotiation of professional identities within professional learning settings in engineering education. While supporting teachers' professional identities was not the original intent of the professional learning community, Ms. Scott's sharing of her experiences required a more intentional understanding of the role of identity within this setting. Specifically, we called upon a positional identities framework to address the question of how hidden issues of power and status within a PLC informed a Black female teacher's negotiation of a teacher-of-engineering identity. Incorporating this lens afforded opportunities for understanding the "sociocultural, sociohistorical, and sociopolitical dimensions" (Mensah, 2012, p. 106) of Ms. Scott's perceptions of having "lesser access to spaces, activities, genres" (Holland et al., 1998, pp. 127–128) and teacher-of-engineering identity within the PLC.

Utilizing a positional identity framework also highlighted how this context, and specific comparisons to the teachers and students represented in this space, informed Ms. Scott's positionality. For instance, although Black students from "inner-city" communities have historically been situated within deficit learning theories (Bang, Warren, Rosebery, & Medin, 2013;

Brown, 2011; Howard, 2013), Ms. Scott recognized that her students were often similarly positioned within the town of Dickerson. Here, the possibility of her students being recognized as doers of engineering, and thus her as a teacher-of-engineering, was reduced when compared against students attending a “STEM magnet school.” Due to variation in status afforded teachers and students from the two participating schools, the research team wondered if Ms. Scott would have conveyed similar sentiments of self if she engaged teachers from a school with a similar status within Dickerson.

An additional contextual component of Ms. Scott’s perception of having limited access to a teacher-of-engineering identity was her positionality as a Black female in a town within the Deep South. Again, although this revelation was reminiscent of hooks’ (1994) discussion of how female teachers of color were often marginalized from educational discussions, even when race and equity were the primary topics, Ms. Scott’s discussions were very much in response to her experiences within Dickerson. Within the context of the PLC and interacting with White female teachers, Ms. Scott acknowledged how being a Black female teacher in the Deep South and its racialized and gendered history would frame how she would be recognized, or not, as a teacher-of-engineering. Again, understanding this sentiment, the research team again considered how Ms. Scott might have negotiated a similar space that consisted of a larger percentage of teachers of color. Hence, the focus on teachers’ positionality afforded the research team opportunities to highlight the importance of the role that context plays in teacher education.

## Implications

We return to Lottero-Perdue’s (2013) assertion that the engineering education community should explore ways of “providing teachers with opportunities to discuss the ways in which they do or do not see themselves—or suspect that others see them—as teachers of engineering” (p. 27). Designers of K-12 teacher learning opportunities in engineering education have been successful at designing innovative experiences that support deeper levels of understanding what engineering is; however, we argue that including additional supports for developing teacher-of-engineering identities is just as essential. Luehmann (2007) contends that spaces for teacher professional development “not only requires opportunities to participate in relevant experiences and the discourse, but [should also] have one’s participation interpreted and recognized, as well as valued and accepted, by self and others” (p. 833). Thus, as the engineering education community grapples with “supporting the representation of minority teachers with interests in engineering” (Diaz et al., 2013), future professional development opportunities could benefit from including what Gee (2005) referred to as “recognition work.” This work would include explicit conversations between teachers and teacher educators regarding the ways in which teacher practices are interpreted, valued, accepted, and recognized as engineering teaching and learning.

The inclusion of recognition work alongside innovative teaching and learning experiences for facilitating engineering activities have important implications for teachers and/or students from historically marginalized communities. During conversations with Ms. Scott, she identified concerns as to whether her Black students would be interpreted and accepted as doers of engineering, thus potentially impacting how peers perceived her as a teacher-of-engineering. This finding highlights the understanding that not all ways of knowing, talking, interacting, and viewing the world are always valued and read equally by schools and society, and, in this case, the discipline of engineering (Douglas, 2015; Slaton, 2010). Ms. Scott’s experiences and perceptions call attention to the idea that the recognition work of interpreting and recognizing participation in the teaching and learning of engineering could be steeped in historic deficit conceptions of race, class, culture, gender, and language (Wright, Wendell, & Paugh, 2018). Acknowledging this potential, we insist that professional development opportunities in engineering education not only include recognition work, but include this work through a lens of interculturality (Warren & Rosebery, 2011). Through this lens, teachers and teacher educators make sense of what it means to recognize teaching and learning in engineering education through discussions of:

Understanding the ways in which diverse points of views, histories, meanings, and sense-making practices come into contact in real time as students and teachers navigate academic subject matter, and likewise understanding that this navigation inevitably takes place at powered boundaries of culture, race, class, and language. (p. 99)

Engaging in recognition work through a lens of interculturality would invite insights from teachers such as Ms. Scott and how their positionality informs their sense of self within the engineering education teaching community. As we make this call for increased recognition work, we also acknowledge that exploring notions of recognition and interpretation through an intercultural lens would not be easy work. Such a venture would challenge teachers and teacher educators to unpack the ways in which interpretation and recognition are powered constructs due to settled expectations (Bang et al., 2012) of participation in both school and the discipline of engineering. Despite these complexities, we argue that providing opportunities for these deep discussions could contribute to disrupting how teachers from historically marginalized communities, like Ms. Scott, are potentially recognized by self and others as teachers-of-engineering.

## Author Bios

**Dr. Christopher G. Wright** is an Assistant Professor of STEM Education in the Drexel University School of Education and Co-Director of the Informal Learning Linking Engineering, Science, & Technology (ILLEST) Lab in Drexel University's ExCITE Center. Dr. Wright conducts research on the design and development of inclusive K-12 science and engineering learning spaces.

Email: [cgw57@drexel.edu](mailto:cgw57@drexel.edu).

Website: <https://drexel.edu/soe/faculty-and-staff/faculty/Wright-Christopher/> and <https://drexel.edu/excite/discovery/illest-lab/>.

**Rasheda Likely** is a fourth-year PhD candidate in STEM Education in Drexel University's School of Education. Rasheda conducts research that investigates the design, development, and facilitation of culturally sustaining curricula and assessments for minoritized middle-school girls.

Email: [rsl67@drexel.edu](mailto:rsl67@drexel.edu).

Website: <https://drexel.edu/soe/academics/doctoral/phd-in-educational-leadership-development-and-learning-technologies/meet-our-students/rasheda-likely/>.

**Dr. Kristen Wendell** is an Associate Professor of Mechanical Engineering and Adjunct Associate Professor of Education at Tufts University, where she leads a research group at the Center for Engineering Education and Outreach (CEEEO) and is a member of the Tufts Institute for Research on Learning and Instruction (IRLI).

Email: [kristen.Wendell@tufts.edu](mailto:kristen.Wendell@tufts.edu).

Website: <https://engineering.tufts.edu/people/faculty/kristen-wendell>.

**Dr. Patricia P. Paugh** is an Associate Professor in the Department of Curriculum & Instruction at the University of Massachusetts Boston. Dr. Paugh's scholarship focuses on collaborative research with teachers in urban schools, specifically around disciplinary and critical literacies. These interests have recently been explored through investigations into the integration of language and engineering practices when teaching urban elementary students.

Email: [patricia.paugh@umb.edu](mailto:patricia.paugh@umb.edu).

Website: [https://www.umb.edu/faculty\\_staff/list/patricia\\_paugh](https://www.umb.edu/faculty_staff/list/patricia_paugh).

**Elizabeth Smith** is a middle-school mathematics instructor in the Knox County Public School system.

## Acknowledgments

A special thanks to Dr. Valerie Klein and Dr. Eli Tucker-Raymond for their feedback and support. The project was funded by National Science Foundation grants 1411660 and 1316762. The opinions expressed herein are those of the authors and not necessarily those of NSF.

## References

- Akerson, V. L., Carter, I. S., & Elcan, N. (2016). On the nature of professional identity for nature of science. In L. Avraamidou (Ed.), *Studying science teacher identity: Theoretical, methodological, and empirical explorations* (pp. 89–110). Rotterdam, The Netherlands: Sense Publishers.
- Avraamidou, L. (2014). Developing a reform-minded science identity: The role of informal science environments. *Journal of Science Teacher Education*, 25(7), 823–843.
- Bang, M., Warren, B., Rosebery, A. S., & Medin, D. (2012). Desettling expectations in science education. *Human Development*, 55(5–6), 302–318.
- Bristol, T. J. (2018). To be alone or in a group: An exploration into how the school-based experiences differ for Black male teachers across one urban school district. *Urban Education*, 53(3), 334–354.
- Bristol, T. J., & Goings, R. B. (2019). Exploring the boundary-heightening experiences of Black male teachers: Lessons for teacher education programs. *Journal of Teacher Education*, 70(1), 51–64.
- Bristol, T. J., & Mentor, M. (2018). Policing and teaching: The positioning of Black male teachers as agents in the universal carceral apparatus. *The Urban Review*, 50(2), 218–234.
- Brown, A. L. (2011). "Same old stories": The Black male in social science and educational literature, 1930s to the present. *Teachers College Record*, 113(9), 2047–2079.
- Capobianco, B. M., DeLisi, J., & Radloff, J. (2018). Characterizing elementary teachers' enactment of high-leverage practices through engineering design-based science instruction. *Science Education*, 102(2), 342–376.
- Carlone, H. B. (2012). Methodological considerations for studying identities in school science: An anthropological approach. In M. Varelas (Ed.), *Identity construction and science education research: Learning, teaching, and being in multiple contexts* (pp. 9–26). Rotterdam, The Netherlands: Sense Publishers.
- Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, 44(8), 1187–1218.



- Charmaz, K. (2006). *Constructing grounded theory: A practical guide through a qualitative analysis*. London, UK: Sage Publications.
- Collins, P. H., & Bilge, S. (2016). *Intersectionality*. Cambridge, UK: Policy Press.
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Thousand Oaks, CA: Sage Publishing.
- Creswell, J. W., & Miller, D. L. (2000). Determining validity in qualitative inquiry. *Theory into Practice*, 39(3), 124–131.
- Danielsson, A. T., & Warwick, P. (2014). Identity and discourse. In L. Avraamidou (Ed.), *Studying science teacher identity: Theoretical, methodological, and empirical explorations* (pp. 71–88). Rotterdam, The Netherlands: Sense Publishers.
- Deneroff, V. (2016). Professional development in person: Identity and the construction of teaching within a high school science department. *Cultural Studies of Science Education*, 11(2), 213–233.
- Diaz, N. V., Cox, M. F., & Adams, S. G. (2013). Elementary educators' perceptions of design, engineering, and technology: An analysis by ethnicity. *Journal of STEM Education*, 14(3), 13–22.
- Douglas, E. (2015). Engineering as a space of White privilege. *Understanding and Dismantling Privilege*, 5(1), 36–44.
- Duncan, D., Diefes-Dux, H., & Gentry, M. (2011). Professional development through engineering academies: An examination of elementary teachers' recognition and understanding of engineering. *Journal of Engineering Education*, 100(3), 520–539.
- Fairclough, A. (2009). *A class of their own: Black teachers in the segregated south*. Cambridge, MA: Harvard University Press.
- Gee, J. P. (2005). *An introduction to discourse analysis: Theory and method* (2nd ed.). New York, NY: Routledge.
- Godwin, A., Potvin, G., Hazari, Z., & Lock, R. (2016). Identity, critical agency, and engineering: An effective model for predicting engineering as a career choice. *Journal of Engineering Education*, 105(2), 312–340.
- Goings, R. B. (2015). The lion tells his side of the (counter)story: A Black male educator's autoethnographic account. *Journal of African American Males in Education*, 6(1), 91–105.
- Holland, D., Lachicotte, W., Skinner, D., & Cain, C. (1998). *Identity and agency in cultural worlds*. Cambridge, MA: Harvard University Press.
- Holland, D., & Leander, K. (2004). Ethnographic studies of positioning and subjectivity: An introduction. *Ethos*, 32(2), 127–139.
- Hooks, B. (1994). *Teaching to transgress: Education as the practice of freedom*. New York, NY: Routledge.
- Howard, T. C. (2013). How does it feel to be a problem? Black male students, schools, and learning in enhancing the knowledge base to disrupt deficit frameworks. *Review of Research in Education*, 37(1), 54–86.
- Hsu, M. C., Cardella, M. E., & Purzer, S. (2010, June). *Assessing elementary teachers' design knowledge before and after introduction of a design process model*. Paper presented at the 2010 American Society of Engineering Education Conference & Exposition, Louisville, KY. <https://peer.asee.org/16289>
- Hsu, M. C., Purzer, S., & Cardella, M. E. (2011). Elementary teachers' views about teaching design, engineering, and technology. *Journal of Pre-College Engineering Education Research*, 1(2), 30–39.
- Johnson, A. W., Wendell, K. B., & Watkins, J. (2017). Examining experienced teachers' noticing of and responses to students' engineering. *Journal of Pre-College Engineering Education Research*, 7(1), 25–35.
- King, D., & English, L. D. (2016). Engineering design in the primary school: Applying STEM concepts to build an optical instrument. *International Journal of Science Education*, 38(8), 2762–2794.
- Lewis, J. A., Mendenhall, R., Harwood, S. A., & Hunt, M. B. (2016). "Ain't I a woman?": Perceived gendered racial microaggressions experienced by Black women. *The Counseling Psychologist*, 44(5), 758–780.
- Lottero-Perdue, P. S. (2013, June). Elementary teacher as a teacher-of-engineering: *Identities in concert and conflict*. Paper presented at the 2013 American Society of Engineering Education Conference & Exposition, Atlanta, GA. <https://peer.asee.org/19487>
- Luehmann, A. L. (2007). Identity development as a lens to science teacher preparation. *Science Education*, 91(5), 822–839.
- Luehmann, A. L. (2008). Using blogging in support of teacher professional identity development: A case study. *Journal of the Learning Sciences*, 17(3), 287–337.
- Maulucci, M. R. (2013). Emotions and positional identity in becoming a social justice science teacher: Nicole's story. *Journal of Research in Science Teaching*, 50(4), 453–478.
- Mensah, F. M. (2012). Positional identity as a lens for connecting elementary preservice teachers to teaching in urban classrooms. In M. Varelas (Ed.), *Identity construction and science education research: Learning, teaching, and being in multiple contexts* (pp. 105–122). Rotterdam, The Netherlands: Sense Publishing.
- Mensah, F. M. (2016). Positional identity as a framework to studying science teacher identity: Looking at the experiences of teachers of color. In L. Avraamidou (Ed.), *Studying science teacher identity: Theoretical, methodological, and empirical explorations* (pp. 49–70). Rotterdam, The Netherlands: Sense Publishers.
- Mensah, F. M. (2019). Finding voice and passion: Critical race theory methodology in science teacher education. *American Educational Research Journal*, 56(4), 1412–1456.
- Mensah, F. M., & Jackson, I. (2018). Whiteness as property in science teacher education. *Teachers College Record*, 120(1), 1–38.
- Merriam, S. B., & Tisdell, E. J. (2016). *Qualitative research: A guide to design and implementation* (4th ed.). San Francisco, CA: Jossey-Bass.
- Milner, H. R. (2007). Race, culture, and researcher positionality: Working through dangers seen, unseen, and unforeseen. *Educational Researcher*, 36(7), 388–400.
- Milner, H. R. (2012). Challenging negative perceptions of Black teachers. *Educational Foundations*, 26(1–2), 27–46.
- Nasir, N. S. (2012). *Racialized identities: Race and achievement among African American youth*. Stanford, CA: Stanford University Press.
- NGSS Lead States. (2013). *Next Generation Science Standards: For states, by states*. Washington, DC: The National Academies Press.
- Pinkney, A. R. (2016). The role of schools in educating Black citizens: From the 1800s to the present. *Theory & Research in Social Education*, 44(1), 72–103.
- Powers, B., & Duffy, P. B. (2016). Making invisible intersectionality visible through theater of the oppressed in teacher education. *Journal of Teacher Education*, 67(1), 61–73.
- Saka, Y., Southerland, S. A., Kittleson, J., & Hunter, T. (2013). Understanding the induction of a science teacher: The interaction of identity and context. *Research in Science Education*, 43(3), 1221–1244.
- Settlage, J., Southerland, S. A., Smith, L. K., & Ceglie, R. (2009). Constructing a doubt-free teaching self: Self-efficacy, teacher identity, and science instruction within diverse settings. *Journal of Research in Science Teaching*, 46(1), 102–155.
- Slaton, A. E. (2010). *Race, rigor, and selectivity in US engineering: The history of an occupational color line*. Cambridge, MA: Harvard University Press.



- Subotnik, R. F., Tai, R. H., Rickoff, R., & Almarode, J. (2009). Specialized public high schools of science, mathematics, and technology and the STEM pipeline: What do we know now and what will we know in 5 years? *Roeper Review*, 32(1), 7–16.
- Sun, Y., & Strobel, J. (2014). From knowing-about to knowing-to: Development of engineering pedagogical content knowledge by elementary teachers through perceived learning and implementing difficulties. *American Journal of Engineering Education*, 5(1), 41–60.
- Szymanski, D. M., & Lewis, J.A. (2016). Gendered racism, coping, identity centrality, and African American college women's psychological distress. *Psychology of Women Quarterly*, 40(2), 229–243.
- Thomas, A. J., Witherspoon, K. M., & Speight, S. L. (2008). Gendered racism, psychological distress, and coping styles of African American women. *Cultural Diversity and Ethnic Minority Psychology*, 14(4), 307–314.
- Tillman, L. C. (2004). (Un)intended consequences: The impact of the Brown v. Board of Education decision on the employment status of Black educators. *Education and Urban Society*, 36(3), 280–303.
- Tonso, K. L. (2006). Student engineers and engineer identity: Campus engineer identities as figured world. *Cultural Studies of Science Education*, 1(2), 273–307.
- Upadhyay, B. (2009). Negotiating identity and science teaching in a high-stakes testing environment: An elementary teacher's perceptions. *Cultural Studies in Science Education*, 4(3), 569–586.
- Valla, J. M., & Williams, W. M. (2012). Increasing achievement and higher-education representations of under-represented groups in science, technology, engineering, and mathematics fields: A review of current K-12 intervention programs. *Journal of Women and Minorities in Science and Engineering*, 18(1), 21–53.
- Vaught, S. E. (2009). The color of money: School funding and the commodification of Black children. *Urban Education*, 44(5), 545–570.
- Warren, B., & Rosebery, A. S. (2011). Navigating interculturality: African American male students and the science classroom. *Journal of African American Males in Education*, 2(1), 98–115.
- Watkins, J., McCormick, M., Wendell, K. B., Spencer, K., Portsmore, M., & Hammer, D. (2018). Data-based conjectures for supporting responsive teaching in engineering design with elementary teachers. *Science Education*, 102(3), 548–570.
- Wendell, K. B., Wright, C. G., & Paugh, P. P. (2017). Reflective decision-making in elementary students' engineering design. *Journal of Engineering Education*, 106(3), 356–397.
- Wright, C. G., Wendell, K. B., & Paugh, P. (2018). "Just put it together to make no commotion": Re-imagining urban elementary students' participation in engineering design practices. *International Journal of Education in Mathematics, Science, and Technology*, 6(3), 285–301.
- Yin, R. K. (2003). *Applications of case study research* (2nd ed.). Thousand Oaks, CA: Sage Publishing.
- Yoon, S. Y., Diefes-Dux, H. A., & Strobel, J. (2013). First-year effects of an engineering professional development program on elementary teachers. *American Journal of Engineering Education*, 4(1), 67–84.
- Yoon, S. Y., Kong, Y., Diefes-Dux, H. A., & Strobel, J. (2018). Broadening K-8 teachers' perspectives on professional development in engineering integration in the United States. *International Journal of Research in Education and Science*, 4(2), 331–348.