UNIVERSITY OF CALIFORNIA SAN DIEGO

CALIFORNIA STATE UNIVERSITY, SAN MARCOS

"How do we help them?" A Professional Learning Community Framework Design Advancing Informal STEM Learning for Black Girls

A Dissertation submitted in partial satisfaction of the
requirements for the degree Doctor of Education

in

Educational Leadership

by

Jasmine Johnson

Committee in charge:

University of California San Diego

Professor Mica Pollock, Co-Chair
Professor Beth Simon, Co-Chair

California State University San Marcos

Professor Rong-Ji Chen

2024

The Dissertation of Jasmine Johnson is approved, and it is acceptable in quality and form for publication on microfilm and electronically.

University of California San Diego

California State University, San Marcos

2024

DEDICATION

I dedicate this Dissertation to the City of San Diego and the uncountable number of lives I have changed for the better during my time in America's Finest City.

To the minds I have blown, to the seeds I have sown, and to my legacy yet unknown.

Thank you for it all!

I love you, Dr. Jas

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

"God did it!" Thank you, Lord, for carrying me through this journey, and answering every prayer along the way. In my final days before submitting this dissertation, I had to remember to start off each writing session in the Word and with prayer. I love you lots!

To my husband, Kamal, thanks for coming into my life in the middle of this doctor journey. You have supported me in multiple ways to become Dr. JJ just before we embark on a new adventure together. One thing I could count on is you saying, "You Got This!" and handing me a plate of food in hopes that it would replace my keyboard for a bit. I appreciate you, and I love you, and congratulations for surviving *our* dissertation!

To my parents, James and Mary Sadler, thanks for encouraging this little Black girl from Detroit to grow up and be a dancing rocket scientist turned Doctor! Thank you for being my STEM inspiration, seeing my interests, and nurturing them ALL.

I would like to acknowledge my committee, Dr. Mica Pollock, Dr. Beth Simon, and Dr. Rong-Ji Chen. Mica, thank you for your unrelenting dedication to me among the many life celebrations you have had. You have shown me that my work is important and so am I. Beth, thanks for living your work and showing me the beauty in Digital Learning. Dr. Chen, thanks for all you do to develop our future STEM educators; I will keep sending people your way!

Lastly, to my Doctor Crew! JDP cohort 17: We did it! Thank you for inspiring me during our graduation celebrations to finish this dissertation and turn it in. It has been a lonely, and intense mental health journey, but it has been wonderful to share it with you all. Black JDP: thanks for your words of wisdom and guidance from a cultural lens as we share our narratives of how we've overcome. My Girls: Dr. Rochelle, Dr. Ardisia, Dr. Sade thanks for making Black Women's History with me in this process and cheering me on as I anchor our race.

VITA

2009 Bachelor of Science in Engineering in Aerospace Engineering, University of Michigan

2014 CEO + Visionary, The STEAM Collaborative

2018 Master of Business Administration, Point Loma Nazarene University

2024 Doctor of Education, Educational Leadership, Joint Doctoral Program of University of California, San Diego and California State University, San Marcos

PUBLICATIONS

Trahan, L., & Baldis, J., & Sadler, J. L., & Lipomi, D. J. (2023, June), *WIP: Approaches to pairing proactive advising and teaching students how to learn* Paper presented at 2023 ASEE Annual Conference & Exposition, Baltimore, Maryland. 10.18260/1-2--44074

ABSTRACT OF THE DISSERTATION

"How do we help them?" A Professional Learning Community Framework Advancing Informal STEM Learning for Black Girls

by

Jasmine L. Sadler Johnson

Doctor of Education in Educational Leadership

University of California San Diego, 2024
California State University, San Marcos, 2024

Professor Mica Pollock, Co-Chair
Professor Beth Simon, Co-Chair

Due to the barriers and trauma that many Black women experience during their educational journey, they are among the most underrepresented groups in the Science, Technology, Engineering and Mathematics (STEM) pipeline (Alfred et al., 2019; Collins et al., 2020; Fouad et al., 2017). Some have argued that starting early with advancing STEM learning

itself for Black girls (Alfred et al., 2019; Carlone & Johnson, 2007; Collins et al., 2020; King & Pringle, 2019; Wade-Jaimes et al., 2021). Also, research suggests that the counterspaces within informal education are crucial sites of STEM learning for Black girls, not just traditional schools (King & Pringle, 2019). Moreover, a large body of research has proven that enabling and supporting their STEM educators and educational leaders to collaborate (Fulton & Britton, 2011; Malcom et al., 1976) including belonging to a Professional Learning Community (PLC) positively impacts student achievement (DuFour, 2004; Fulton & Britton, 2011; Hord, 2004; Rhoulac Smith et al., 2008). However, PLCs do not typically exist in informal education, resulting in its practitioners working independently in silos (Jeffs & Smith, 2021) – and few if any supports seem to exist for practitioners of informal education to better support Black girls in STEM specifically. Combining these points, this study sought to engage informal educators and educational leaders in dialogue about research-based solutions to support Black girls in STEM, and how a PLC might be designed to complement their efforts. This dissertation asked practitioners of informal STEM learning *themselves* to read empirical research, engage in focus group dialogue, and complete reflection questionnaires to collectively make sense of and address a major crisis in education - the underrepresentation and attrition of Black girls in the STEM pipeline (Alfred et al., 2019). The purpose of this participatory action research was to explore recommendations on the most effective content knowledge and pedagogical design. Based on the findings, this dissertation proposes a framework for Professional Learning Communities advancing informal STEM learning for Black girls.

CHAPTER 1: INTRODUCTION

Introduction to the Context and Nature of the Study

Since 2001, the United States has been at risk of losing its economic and intellectual lead compared to other countries (Hallinen, 2021). To mitigate this risk, the National Science Foundation called for a new focus on Science, Technology, Engineering, and Mathematics (STEM) to build a globally competitive workforce (Committee on Equal Opportunities in Science and Engineering, 2000). The necessity to improve STEM Education was also reflected in President Obama's Educate to Innovate campaign (The White House, Office of the Press Secretary, 2009).

While these policies attempt to improve STEM access and matriculation, STEM education continues to proceed in a way that does not attract, retain, or graduate Black women (Farinde & Lewis, 2012). At the university level, 32% of women switch out of STEM degree programs, or become disengaged and opt for non-STEM subjects (Marsh et al., 2019; Chen, 2013). Black women earn only 3% of STEM degrees and certificates (National Center for Education Statistics, 2023). Black women continue to leak out of the STEM pipeline due to barriers and trauma that many experience while pursuing STEM learning, starting in the earliest years of education (Alfred et al., 2019; Fouad et al., 2017). More specifically, Black girls' STEM interest declines in the middle years (Pinkard et al., 2017). Reasons for the attrition of Black girls in STEM include other people's biases against them (Williams, 2015), and their low expectations of themselves (Crisp et al., 2009; Marsh et al., 2019).

Researchers have wondered, then, how preparing practitioners of STEM learning can be one factor needed to retain underrepresented students in STEM (Birney & McNamara, 2019). The practitioners of informal STEM learning that we will focus on in this study are program

educators (teachers) and organization educational leaders (executive directors, administrators). Research suggests that students who succeed are taught by educators who understand how they learn, and these educators encourage them to explore STEM-related careers (Birney & McNamara, 2019). Increasing the quality of STEM educators can help students think critically, creatively, and collaboratively (Burrows & Slater, 2015). Additionally, educational leaders are the ones who can use current frameworks to model success (Leithwood et al., 2008) and impact the educational climate for their students (Baker et al., 2021). Self-awareness by those leaders, as they direct programming for students of color, may create a more inclusive and culturally responsive education system (Flores III, 2020). Ideally, these educational leaders are aware of how racism and stereotyping impact their students, acknowledge that oppressive system, and partner with others to overcome oppressive barriers within schools and organizations (Lindsey et al., 2018). For example, informal STEM educational leaders are in charge of counterspaces that can empower Black girls with a STEM identity that may help them make sense of their traditional school curriculum (King & Pringle, 2019). Perhaps, informal STEM learning could provide a more holistic approach to empowering Black girls' STEM identity (King & Pringle, 2019). Therefore, this dissertation presents empirical research *to* practitioners of informal STEM learning in an attempt to increase such *self*-awareness, and asks them how a Professional Learning Community (PLC) could be designed for them to better serve Black girls.

Statement of the Problem

In the United States, over two million Science, Technology, Engineering, and Mathematics (STEM) jobs will go unfilled by 2025 (Giffi et al., 2015). Black women and girls continue to leave the STEM pipeline (Alfred et al., 2019; Fouad et al., 2017) ultimately due to institutional racism, and systemic oppression (Singleton, 2015), along with their daily

educational experiences (Collins et al, 2020; King & Pringle, 2019; Pinkard et al., 2017; Pollock, 2017). Black middle school girls express high interest in science engagement, but low interest in pursuing science-related careers (Wade-Jaimes & Schwartz, 2018). With underrepresentation in STEM degrees, Black girls cannot gain the required qualifications to access the unfilled STEM jobs (Cantor et al., 2014). This is a social issue that will further widen the achievement gap, pay gap, and wealth gap for women and the Black community (Alfred et al., 2019; Farinde & Lewis, 2012). Such pipeline disparities for Black girls in STEM learning start early (Alfred et al., 2019; Collins et al., 2020; Pinkard et al., 2017; Scott & White, 2013), but can also be rectified early (Dixon-Payne, 2022; King & Pringle, 2019; Morton & Smith-Mutegi, 2022; Pinkard et al., 2017; Scott & White, 2013). Therefore, Black girls in grades K-12 are the underrepresented STEM student population focused on in this work.

Existing research indicates that the leaders of STEM programs need to be developed and supported to, in turn, support Black girls through the STEM pipeline (Fulton & Britton, 2011). Research indicates that teachers who increase their professional learning by incorporating research-based solutions have higher levels of student achievement (ACER, 2016). In particular, informal educators in professional learning can shift their conversations from their program logistics to conversations that analyze the pedagogy and praxis of their programs (Tran et al., 2013). However, informal STEM educators have few opportunities for such professional development, and reflection with their colleagues (Heimlich, 2021; Swanson, 2018). Thus, this research specifically targets current informal STEM learning practitioners.

Also, a large body of research has proven that a Professional Learning Community (PLC) can positively impact student achievement (DuFour, 2004; Fulton & Britton, 2011; Hord, 2004; Rhoulac Smith et al., 2008). Members of PLCs within education can apply their professional

learning to their students (Townley, 2020; Heimlich et al., 2021). However, no current literature explores how to *design* a PLC *to support Black girls in informal STEM learning*. What if we asked the educators and educational leaders themselves? Therefore, this dissertation seeks to ask practitioners of informal STEM learning *themselves* what learning supports they need to better support Black girls in STEM. We start with the professional learning aspect of a PLC by inviting educators and educational leaders to read empirical research about Black girls in STEM, then discuss applications to their work.

Definition of Terms

The following definitions are significant to this study:

Black Black is a signifier for people or persons who self-identify as Black or African American and are descendants of Africans (a part of the African Diaspora). This word refers to people with origins in any of the Black racial groups of Africa or persons with ethnic origins in the Black racial groups of the Caribbean, Central America, South America, and other world regions.

Informal Education or Informal Learning Informal Education refers to education outside of the formal or traditional school setting (Jeffs & Smith, 2021). This field mainly involves before-school, after-school, out-of-school, or summer activities.

Intersectionality Kimberlé Crenshaw coined the term intersectionality, which describes the multidimensional interconnected social identities that overlap with racist and oppressive encounters (Delgado & Stefancic, 2017). For Black women and girls, constructs such as race, gender, class, and other social categories overlap and contribute to systemic oppression and discrimination (Crenshaw, 2017).

Pedagogy Andragogy is an adult-focused teaching approach. Adults learn in a different way than children learn. The methods used to teach children (pedagogy) are not always effective ways to

teach adults. Still, pedagogy is a term popularly used for the method of teaching, so it will be used in this dissertation when referencing child and adult learning.

Professional Learning Community (PLC) An ongoing process in which educators are supported to work collaboratively in recurring cycles of collective inquiry and action research to develop knowledge and skills to improve student outcomes (DuFour, 2004; DuFour et al., 2016; Townley, 2020).

Science, Technology, Engineering, and Mathematics (STEM) STEM is an acronym for Science, Technology, Engineering, and Mathematics that describes units of study and academic disciplines.

STEM Identity In this study, a STEM identity is achieved when an individual makes meaning of their STEM experiences, and when STEM professionals confirm those meanings (Carlone & Johnson, 2007). A strong STEM identity is exhibited by feelings of competence, efficacy, and confidence in understanding and applying STEM content and procedures (Collins et al., 2020).

Purpose of the Study

Research suggests that building shared knowledge upfront results in faster, more committed, and more effective action within a PLC (DuFour, 2016); which was paramount in this study's PLC. To learn how to support Black girls in STEM, research suggests that their educators need to engage more with culturally responsive research on Black girls, their STEM identity, and how Black girls perceive their academic experience (Brickhouse et al., 2000). Faculty biases and stereotypes can also contribute to students' self-efficacy (McGee & Martin, 2011; Kraft, 1991), so educational leaders must explore these too. Instead of fixing schools and the students, educational leaders must move to a new framework that challenges and reimagines education through informal education (Bevan et al., 2010). Plus, a PLC values a strong and

consistent focus on learning for educators in a collaborative culture of shared ownership, responsibility, and success among teachers for their students (DuFour, 2004). Therefore, a PLC can perhaps be a new mechanism needed for educators and educational leaders, including those in informal learning, to support the experience and achievement of Black girls in STEM.

In general, research suggests that a successful PLC constantly builds participants' capacity to teach well by learning from research and having a reflective dialogue with their colleagues (ACER, 2016; Tran et al., 2013). Informal STEM educators and educational leaders in a PLC may discover research-based solutions to the issues they are facing by engaging with empirical research on those issues. Additionally, professional learning is sparked by the lived experiences of the participants themselves (Townley, 2020; Heimlich et al., 2021). This dissertation thus sought to explore deeper questions of how educators reacted to research *about* supporting Black girls. Also, this dissertation sought to engage informal educators and educational leaders in collectively designing PLC supports to advance informal STEM learning for Black girls. ***The purpose of this study was to explore recommendations for the content knowledge and pedagogical design of a Professional Learning Community Framework advancing informal STEM learning for Black girls.***

Research Questions

To find out how to design a PLC to advance informal STEM learning for Black girls, the following research questions guided this study:

1. In dialogues about research-based supports for Black girls, how do practitioners of informal STEM learning make sense of empirical research as they consider race, gender, and class in their own work?

2. In what ways do practitioners of informal STEM learning propose the design of a Professional Learning Community to help them more positively affect the educational experiences of Black girls?

Methods

This Participatory Action Research (PAR) study used a qualitative approach to gain insight into the perceptions of informal STEM educators and educational leaders on professional learning that they themselves need when a) presented with research, b) led through focus group dialogues and reflection, and c) interviewed about how best to support their own work with Black girls. This study explored the perceptions among practitioners of informal STEM learning that emerged as they examined empirical research with other similar practitioners, and combined it with their lived experiences in education. Furthermore, the voices of Black girls and their experiences with STEM learning was included within the empirical research itself, which was read by participants to spark inquiry and build shared knowledge. Using this study as an intervention, the researcher engaged informal STEM educators and educational leaders in dialogue about the content knowledge they need, and how a PLC might be pedagogically designed accordingly to advance informal STEM learning for Black girls.

There are many adults that support the growth and development of children in STEM, but this study specifically focused on informal STEM educators and educational leaders. Informal education can offer Black girls a more holistic approach to STEM learning that allows them to make connections to traditional learning environments and supports their science identity (King & Pringle, 2018). Research also suggests that ensuring an aligned culture and communication of educational leaders can improve student pursuit of STEM disciplines (Kirst & Venezia, 2004). In a traditional education system, collective leadership requires the influence of teachers, parents,

principals, district office staff, and community members toward a shared goal (Wahlstrom et al., 2010). On the contrary, many practitioners of informal education serve in isolation. Their isolation causes problems because their silos can block their ability to recognize risks and innovate viable solutions for the educational development of their students (Jeffs & Smith, 2021). This study thus sought to create the rare opportunity within a temporary PLC to create a collaborative culture for informal STEM educators and educational leaders, focused specifically on identifying the professional learning they themselves needed to better support Black girls.

Since this is a Participatory Action Research Study, each participant went through their own individual experience, and made recommendations in their own words. Thematic analysis was used for data analysis to examine participants' perspectives and notice relationships, similarities, and differences in data (Braun & Clarke, 2006; Ravitch & Carl, 2020). The researcher also tapped the Critical Race Feminism (CRF) framework to identify themes that participants mentioned around race, gender, and class of their students in both theory and praxis (Dixon-Payne, 2022; Wing, 2003). The focus group transcripts, reflection questionnaires, and interview transcripts were coded by looking for patterns that emerge, especially as they pertain to CRF and, more broadly, the research questions of this study.

Significance of the Study

Since traditional education was designed, student demographics have changed substantially. Research has shown that the lack of access to quality STEM education is one reason why Black people are underrepresented and underserved in the STEM pipeline (Committee on Equal Opportunities in Science and Engineering, 2000; Funk & Parker, 2018). That lack of access is ultimately a result of institutional racism, and systemic oppression (Singleton, 2015), while daily educational experiences along the way accumulate to these

outcomes (Collins et al, 2020; Pinkard et al., 2017; Pollock, 2008, 2017). Black girls' worldviews, actions, and outcomes are shaped by the intersectionality of racial, gender, and class oppression (Dixon-Payne, 2022; Lindsay-Dennis, 2015). Thus, this research sought to intentionally explore whether engaging education practitioners in studying the educational experiences of Black girls in STEM, and exploring together how to support Black girls more effectively, could provide insight for transformational changes to the pedagogical design of education.

Education needs systemic change that intentionally includes the culture of Black women and girls. Research shows that education should include culturally relevant teaching strategies and acknowledge the contributions of Black women in STEM (Farinde & Lewis, 2012). It is acceptable and necessary to intentionally address the social justice and educational equity needs of underserved and underrepresented populations (Committee on Equal Opportunities in Science and Engineering, 2000; Santamaria & Jean-Marie, 2014). Critical Race Feminism and Black Feminist Thought are two frameworks that emphasize the significance of Black women. In the current educational and political climate, it is imperative that advocacy groups, individuals, organizations, schools, colleges, and universities search together for effective approaches to improve access to higher education (McClafferty et al., 2009). Collaborations between stakeholders, as in this dissertation, create a unique culture that reflects the combined, evolving perspectives of the multiple partners (Hodge et al., 2020; McClafferty et al., 2009). In summary, this study is significant because practitioners of STEM learning must collaborate and consider the lived experiences of Black girls to make transformational changes for them within STEM learning.

Assumptions, Limitations, and Delimitations

While there are many areas that can be explored within STEM education research, this study sought to focus on the adult practitioners of informal STEM learning for students in kindergarten through twelfth grade in San Diego County. The complexity of informal STEM learning is important for rethinking formal schools (Bevan et al., 2013). For example, informal STEM learning can help Black girls make the connection to the STEM subjects they learn in schools (King & Pringle, 2019). Research indicates that the educational leaders in a successful PLC are student-centered, and student-focused (Buttram & Farley-Ripple, 2016). Also, educational leaders have an ethical responsibility to support children's education (Biddle et al., 2018) with a measurable effect on student achievement (Biddle et al., 2018; Buttram & Farley-Ripple, 2016; Leithwood et al., 2008). Even more directly, educators are the ones who understand their students' learning and can encourage them to explore a STEM identity (Birney & McNamara, 2019). Increasing the quality of STEM educators may help their students think critically, creatively, and collaboratively (Burrows & Slater, 2015). Therefore, the assumption of this dissertation was that by focusing on educators and educational leaders, the students they serve will also be positively affected. The results of this study could be generalizable to practitioners of informal STEM learning who (a) serve students in grades K-12, and (b) provide services within San Diego County.

Conclusion

A large body of research has proven that a Professional Learning Community (PLC) positively impacts student achievement (DuFour, 2004; Fulton & Britton, 2011; Hord, 2004; Rhoulac Smith et al., 2008). Moreso, PLCs for practitioners of STEM learning contribute to the retention of their students in the STEM pipeline (Alfred et al., 2019; Fulton & Britton, 2011;

McClafferty et al., 2009). However, PLCs and other opportunities for professional learning – including dialogue and self-reflection – do not typically exist within informal education (Jeffs & Smith, 2021). Therefore, this dissertation study sought to present empirical research data to informal STEM educators and educational leaders, and asked them how to design a PLC to support Black girls in STEM.

CHAPTER 2: REVIEW OF THE LITERATURE

Introduction

In the United States, over two million Science, Technology, Engineering, and Mathematics (STEM) jobs will go unfilled by 2025 (Giffi et al., 2015). In addition to being more plentiful, STEM jobs are often better paid than many other jobs (Smithsonian Science Education Center, 2016). There is a lack of representation of Black professionals in the STEM workforce, due in part to discrimination and the lack of quality education (as discussed earlier) (Funk & Parker, 2018). Additionally, students who experience the intersectionality of race, gender, ethnicity, and class identities are the most underrepresented in STEM (Cantor et al., 2014). Hence, the underrepresentation of Black women in STEM means these individuals then lack the required qualifications to access the plentiful, better-paid, unfilled STEM jobs. Thus, it is vitally important to more critically understand the lack of representation of Black women in STEM.

Although race categories are socially constructed based on assumptions (McChesney, 2015; Spencer et al., 2001; Wing, 2003), race and racism have very real implications. For example, Black girls and women continue to have disproportionately low numbers in achieving STEM degrees (Collins et al., 2020). Black women earn only 3% of STEM degrees and certificates (National Center for Education Statistics, 2023). Black women continue to leak out of the professional STEM pipeline due to barriers and trauma that many experience while pursuing a STEM degree (Alfred et al., 2019; Fouad et al., 2017). This underrepresentation is a social issue that will further widen the achievement gap, pay gap, and wealth gap for women and the Black community (Alfred et al., 2019; Farinde & Lewis, 2012). In spite of this issue, the leak in the pipeline can be mended if students have role models, self-motivation, and a supportive

learning environment (Carlone & Johnson, 2007; Collins & Jones Roberson, 2020; Ireland et al., 2018; Johnson et al., 2019).

There are many factors that research suggests contribute to the achievement gap for underrepresented students. Simply being underrepresented, and not seeing people of the same race can have a negative effect on academic performance (Gregory et al., 2010; Pinkard, 2017). Race, family, poverty, community, language, and mobility may also affect a student's learning (Singleton, 2015). Black students tend to be unfairly compared to their White counterparts, and thus outperformed by them (Collins et al., 2020; Milner, 2012; Ladson-Billings, 2013). Furthermore, the experiences of Black women in STEM are not completely represented because they are sometimes grouped with the experiences of Black men or White women (Collins et al., 2020). These achievement gap calculations are informed by static and standardized measurements while Black students experience dynamic and non-standardized conditions (Tollefson & Magdaleno, 2016). A hyperfocus on the achievement gap puts the accountability on individual students or groups rather than recognizing the institutional and systemic barriers as the problem. While comparative achievements based on race, gender, and class should be acknowledged to address existing accountability, the higher goal should be to improve student achievement – here, supports for Black girls in STEM.

In an attempt to frame this study, I address literature on three themes: (a) big ideas about the underrepresentation of Black girls in STEM (Burnett et al., 2023), (b) a series of empirical research projects that verifies many promising practices to empower Black girls' STEM identity (Collins & Jones Roberson, 2020; Ireland et al., 2018), and (c) studies that explore a Professional Learning Community (PLC) as a complementary solution for student learning and achievement (DuFour, 2004; Hord, 2004), specifically advancing informal STEM learning for Black girls

(Fulton & Britton, 2011; Rhoulac Smith et al., 2008). Additionally, including informal STEM learning offers a more holistic learning approach for Black girls than only focusing on traditional schools, possibly giving girls counterspaces to make sense of what they learn at school (Bevan et al., 2010; King & Pringle, 2018; Wade-Jaimes et al., 2021). PLCs devoted to underrepresented students in STEM focus on professional learning (Townley, 2020; Heimlich et al., 2021), include the educators who are closest to student learning (Birney & McNamara, 2019; Fenichel & Schweingruber, 2010), use the collective leadership of educational leaders (Buttram & Farley-Ripple, 2016; Fulton & Britton, 2011; Hargreaves, 2003), and collaborate with community stakeholders to create a culture of success (Fulton & Britton, 2011; Malcom et al., 1976; McClafferty et al., 2009). I now turn to Critical Race Feminism as the theoretical framework that is most relevant to this dissertation and invite the practitioners of informal STEM education to design a Professional Learning Community that intentionally considers Black girls in both theory and praxis.

Theoretical Framework - Critical Race Feminism

> We as Black women can no longer afford to think of ourselves or let the law think of us as merely the sum of separate parts that can be added together or subtracted from, until a White male or female stands before you. The actuality of our layered experience is multiplicative. Multiply each of our parts together, 1 X 1 X 1 X 1 X 1, and you have one indivisible being. If you divide one of these parts from one you still have one. (Wing, 1997, p. 31)

This dissertation is based on the assumption that traditional STEM learning is largely flawed and unjust for Black girls (Bevan et al., 2010; Clark, 2007; Joseph et al., 2017), and that to create a solution for Black girls, one cannot simply add together solutions for girls to solutions for Black students (Carter Andrews et al., 2019; Evans-Winters & Esposito, 2010; King & Pringle, 2019). For this reason, a framework of Critical Race Feminism (CRF) aids us to interpret the literature about Black girls in informal STEM learning. CRF was chosen as a

framework because there has been little focus on the educational needs of Black girls in general, so more scholarship is needed in the field to examine their unique educational experiences (Evans-Winters & Esposito, 2010). For Black female students, CRF is a particularly useful framework for studying, analyzing, critiquing, and celebrating their own educational experiences (Evans-Winters & Esposito, 2010). Notably, CRF in education addresses the social, economic, political, and educational problems confronting Black female students inside and outside of the traditional school setting (Evans-Winters & Esposito, 2010). In fact, CRF has already been applied to STEM education to further examine solutions to advance STEM learning for Black girls (King & Pringle, 2019). For the purpose of this study, it is necessary to use CRF as a theoretical framework because it is one of few that specifically addresses enriching Black girls' education experience and their quality of life (Dixon-Payne, 2022; Evans-Winters & Esposito, 2010).

CRF has some aspects derived from Critical Legal Studies (CLS), Critical Race Theory (CRT), and feminism, but CRF is still uniquely its own framework that is anti-essentialist (Wing, 2003). *Essentialism* is the view that categories of people, such as all women or all people of color, feel one way on a subject, and the essential voice of white women or men of color, respectively, is chosen to represent Black women (Evans-Winters & Esposito, 2010; Wing, 2003). CLS featured lawsuits against race discrimination or sex discrimination but rejected lawsuits on behalf of Black women that were against the intersection of race *and* sex discrimination (Crenshaw, 2017). CRT seeks to transform the relationship between race, racism, power, and oppression (Delgado & Stefancic, 2017; Morton, 2022). However, CRF theorists have separated themselves from CRT by countering the essentialization of all minoritized people, including Black women (Wing, 2003). For example, research shows that many Black

girls experience education differently from boys of color (Evans-Winters and Esposito, 2010; Wade-Jaimes et al., 2021). In a similar manner, feminist discourse has traditionally allowed White middle-class women's experiences to represent the experiences of all women, including Black women (Wing, 1997). Again, CRF is anti-essentialist and recognizes the multiple identities of women of color (Dixon-Payne, 2022; Evans-Winters & Esposito, 2010; Wing, 1997). As a result, this qualitative study tapped Critical Race Feminism (CRF) as a guide to help analyze the research data (see Methodology).

One argument against CRF is that individual Black girls have experiences that are different from one another, and that lumping their experiences together as *Black girls* is inherently still essentialist. Nevertheless, CRF theorists understand that it is necessary to be strategically essentialist (remaining open to naming truly shared experiences) to be able to theorize, and thus advocate for Black girls collectively (Wing, 2003). Black girls deserve a theoretical framework that combats racial and gender oppression across many disciplines (Wing, 2003). Therefore, many of the studies within this literature review feature experiences of individual Black girls that were synthesized to describe their unique experiences and perspectives. This dissertation assumed that applying CRF to examine the educational experiences of Black female students may provide both theory and praxis solutions to avoid gender and racial essentialism, and to eradicate race, class, and gender oppression in educational institutions (Evans-Winters & Esposito, 2010).

Furthermore, increased attention should be given to the nearly untapped market of students in STEM fields who are members of intersecting marginalized groups. For Black girls, constructs such as race, gender, class, and other social categories overlap and contribute to a unique form of systemic oppression, different from the oppression experienced by Black men

and White women (Crenshaw, 2017; Evans-Winters & Esposito, 2010; King & Pringle, 2019; Morton & Smith-Mutegi, 2022). Kimberlé Crenshaw coined the term *intersectionality*, which describes the multidimensional interconnection of social identities that overlap with racist and oppressive encounters (Delgado & Stefancic, 2017). Due to the social identities, psychological processes, and educational outcomes of underrepresented students, innovative solutions have been found for problems that have not been addressed before (Committee on Equal Opportunities in Science and Engineering, 2000; Ireland et al., 2018). Thus, the unique background and cultural traditions of minoritized women, along with their subsequent experiences and perspectives allow them to bring dramatically new approaches to scientific discovery and innovation (Ong et al., 2011).

With the theoretical framework of Critical Race Feminism in mind, the following literature review takes a deep dive into three areas of focus that will guide professional learning for informal STEM educators and educational leaders. The sections give tools directly to practitioners of informal STEM learning to support Black girls. The diagram in Figure 1 thus represents the three areas of focus with bodies of literature as an outline to advance informal STEM learning for Black girls.

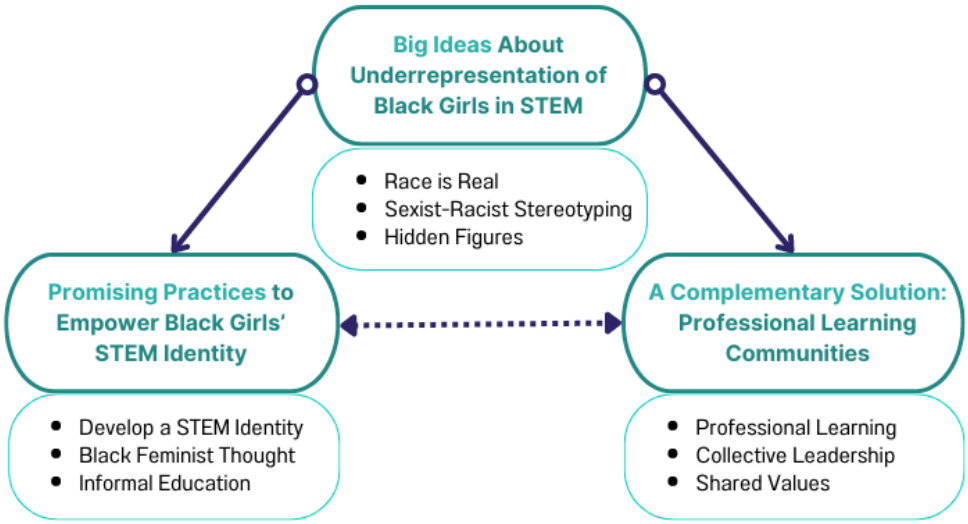

Figure 1: Outline of Professional Learning

Big Ideas about the Underrepresentation of Black Girls in STEM

As the body of research grows on underrepresentation in STEM, students who identify as Black girls are often hidden figures (Ireland et al., 2018; Scott & White, 2013) with lower expectations than their classmates (Morton & Smith-Mutegi, 2022). The intersectionality of race and gender experiences in education is often neither considered nor addressed, even by researchers (Evans-Winters & Esposito, 2010; Howard-Hamilton, 2003; Ireland et al., 2018). As a result, the majority of the research on underrepresentation in STEM focuses on People of Color or Black students or females, but rarely the intersection of these identities. Focusing on women separately from minorities in STEM risks treating these two groups as mutually exclusive and hides the voices of individuals who exist as members of both groups (Ireland et al., 2018; Malcom et al., 1976). However, valuing the perspective and experiences of Black women can reduce the tendency for others to overlook, downplay, or underestimate their success (Farinde & Lewis, 2012; Howard-Hamilton, 2003; Morton & Smith-Mutegi, 2022; Zamudio et al., 2011). Moreover, focusing on the intersectionality of Black women in STEM will provide informative

learning for all underrepresented groups (Evans-Winters & Esposito, 2010; Farinde & Lewis, 2012).

Race is Real

There are many critiques of the construct of race. Race and its corresponding social status have been socially constructed based on assumptions (McChesney, 2015; Spencer et al., 2001; Wing, 2003). Race is historically a social construct; thus, CRT is known as the social construction thesis (Wing, 2003). Science has shown that biological races do not exist. In fact, some people of the same race are more genetically different than people of a different race (McChesney, 2015). Although race is socially constructed, race and racism have very real implications.

Sexist-Racist Stereotyping

There are many ways that the social construct of race and the reality of racism impacts the educational experience of Black students. One important expression of American racism is racial stereotyping (Spencer et al., 2001; Burnett et al., 2023). There is no biological correlation between skin color and intelligence, even as stereotypes assume there is (McChesney, 2015). Stereotyping groups of people is mostly based on the very present, yet ignored impacts of racism (Spencer et al., 2001). Beyond stereotyping, a student's perception of teacher attitudes and supportiveness also contributes to the students' self-efficacy (King & Pringle, 2019; Kraft, 1991, Pinkard et al., 2020). When a student's perception relies on others' biases and stereotypes, it can lead to hurtful results, including them leaving the STEM field altogether (Burnett et al., 2023; Pinkard et al., 2017; Pinkard et al., 2020). Thus, educators need to consider how to value Black girls' own experiences of bias as their truth (Kraft, 1991; Wade-Jaimes & Schwartz, 2019).

Since there is a strong correlation between educational leadership and student achievement (Hodge, 2020; Welborn, 2019), in addition to leaders considering their students' educational experiences, it is essential for leaders to monitor their *own* responsibility in STEM equity, access, and inclusion (Welborn, 2019). *Dynamics of Difference* occur when a system of one culture interacts with a population from another, and both may misjudge the other's actions based on learned expectations (Cross, 1989). Students of color outnumber teachers of color who may actually value their students' unique lived experiences (Zamudio et al., 2011). In a practice known as the pygmalion effect, low expectations from teachers may negatively influence the academic performance of school-age children, leading to disengaged Black students (Howard, 2013; Morton & Smith-Mutegi, 2022). One way to advance STEM learning for underrepresented scholars is to reduce the dynamics of difference and have more culturally responsive STEM educators and leaders (Collins, 2018; Collins et al., 2020).

Unfortunately, some Black students in STEM sacrifice their own cultural identity as a tactic to elude such stereotyping (McGee, 2016; McGee & Martin, 2011; Zamudio et al., 2011). These students rely heavily on *stereotype management*, which is a coping strategy that masks their authentic racial identities (Brickhouse et al., 2000; McGee & Martin, 2011). Even though students want to represent their identities, they can be pressured to assimilate into the campus culture (Museus, 2013). However, these strategies create internal conflicts such as high anxiety, unmanaged anger, imposter syndrome, and work addiction (McGee, 2016; McGee & Martin, 2011). For Black female students to succeed in school, they must pass for someone they are not: the White American female and, ultimately, the White American male (Brickhouse et al., 2000; Fordham, 1993). However, the desire to celebrate their own diversity, while battling a racist,

patriarchal society can be too much for some Black women to handle, and be another reason why they leave STEM (Burnett et al., 2023; Fordham, 1993).

Hidden Figures: The Impact of Racism

As a result of race and racism, many Black girls are not considered in STEM curriculum, pedagogy, programming, or as STEM learners (Bevan et al., 2010; Carter Andrews et al., 2019; Collins et al., 2020). Traditional STEM education fails to include and engage a significant portion of society including women and non-dominant communities (Pinkard et al., 2017; Pinkard et al., 2020). Even more broadly, on a global scale, women of color are forgotten (Clark, 2007; Scott & White, 2013). This results in them being voiceless, invisible, and hidden (Ireland et al., 2018; King & Pringle, 2019). Colorblind, neutral, pro-Black, or pro-women initiatives do not fully explore the intersectional voice or visibility of women of color (Clark, 2007; Evans-Winters & Esposito, 2010; Malcom et al., 1976; McGee & Robinson, 2019; Wing, 2003).

Many have argued that STEM programs need to be redesigned in a way that is no longer color-blind and unjust (King & Pringle, 2018; McGee & Robinson, 2019; Morton & Smith-Mutegi, 2022; Pinkard et al., 2020; Wade-Jaimes & Schwartz, 2019). Actions and discourse that would support STEM learning and development for Black girls in schools are missing (Wade-Jaimes & Schwartz, 2019). This lack of support leads to Black girls' STEM identity only being confirmed when they are quiet, polite, passive, and fast workers (Wade-Jaimes & Schwartz, 2019). This can mean that they have no meaningful engagement with STEM and are unfairly marginalized (Wade-Jaimes & Schwartz, 2019). However, there is proven success in education systems that have an intentional focus on their Black women students. For example, Historically Black Colleges and Universities (HBCUs) graduate almost half of the Black women who earn degrees in STEM disciplines nationwide (National Science Foundation, 2019). The success of

HBCUs shows that when Black girls are directly considered and included in STEM learning, it can empower them in a purposeful way.

Promising Practices to Empower Black Girls' STEM Identity

Researchers have acknowledged that it may be difficult for Black girls to successfully develop a STEM identity based on the conflicting messages they receive regarding racial, gender, and scientific identities in education (Charleston et al., 2014; Ireland et al., 2018; Pinkard, 2019; Wade-Jaimes & Schwartz, 2019). Thus, researchers who have focused on informal STEM for Black girls have found that including them in the program design can increase their interest in STEM and their STEM identity (King & Pringle, 2018; Morton & Smith-Mutegi, 2022; Pinkard et al., 2017; Pinkard et al., 2020).

Educational leaders too should be intentional about providing culturally relevant course materials and programming to Black students (Howard-Hamilton, 2003). Additionally, the pedagogical design of classroom assignments can allow Black girls to find themselves within their learning (Howard-Hamilton, 2003; Morton & Smith-Mutegi, 2022). For example, in one study, Black girls viewed their *formal* science learning as passive and lacking context. Contrary to that, they viewed informal STEM learning as active and hands-on, much like their personality type (Pinkard, 2017; Wade-Jaimes et al., 2021). Many Black girls have difficulty finding an identity in STEM and imagining themselves in STEM roles (Pinkard et al., 2020). To empower Black girls, research suggests that they must first develop a STEM identity, then Black Feminist Thought can be introduced to reaffirm their importance to the field, and Informal Education can be used as a counterspace to connect the STEM subjects they learn in school. This section reviews literature on promising practices to empower Black Girls' STEM identity through Black

Feminist Thought, Informal Education, and empirical research on programs designed for Black girls in STEM.

Develop a STEM Identity

It is possible for underrepresented students to develop a STEM identity (Collins, 2018; Collins et al, 2020; Ireland et al., 2018). Ensuring strong pre-college STEM experiences is one critical factor for students who develop a STEM identity (Collins et al, 2020; Escobar & Qazi, 2020; King & Pringle, 2018; Morton & Smith-Mutegi, 2022; Pinkard et al., 2017; Pinkard et al., 2020; Scott & White, 2013). Early learning experiences help students to understand and apply science content (Carlone & Johnson, 2007; Escobar & Qazi, 2020). For Black girls, a STEM identity is also developed when they have *role models* in STEM who they can see and learn from (Collins et al., 2020; Johnson et al., 2019; Pinkard, 2019). *Confidence* and *self-motivation* are also highlighted as key even when the curriculum is not engaging (Collins & Jones Roberson, 2020). Alternatively, when the curriculum is relevant and engaging, *perseverance* and *persistence* are still needed to develop a STEM identity (Crisp et al., 2009; Joseph et al., 2017). Persistence can also be increased by students' positive experiences with socio-emotional and culturally supportive communities (Burt et al., 2019; Joseph et al., 2017; Pinkard et al., 2020).

Developing a STEM identity among young women can be done by broadening the prototype of who pursues STEM courses and careers (Carlone & Johnson, 2007; Pinkard, 2019). Student perceptions of who belongs in the STEM field can be changed through intervention and educational programs (Joseph et al., 2017; Kim et al., 2018), leading students to self-identify as scientists, technologists, engineers, or mathematicians. However, research also mentions that views of social behaviors as "non-feminine" may work against their teachers' perception of a good science student (Wade-Jaimes & Schwartz, 2019). For example, a Black girl exhibiting an

assertive personality may have a teacher withhold recommendations for advanced science classes (Brickhouse et al., 2000; Wade-Jaimes & Schwartz, 2019). Ultimately, girls can form a STEM identity if they believe they naturally belong in STEM (Carlone & Johnson, 2007; Wade-Jaimes et al., 2021).

Black Feminist Thought

Beyond having role models who look like them, Black girls need big ideas that defy racial and gender oppression across multiple disciplines (Evans-Winter & Esposito, 2010). Black girls need to understand that Black women and their experiences are important (Collins, 2022)! While experiencing the double bind of sexism and racism, Black girls persisting in STEM is itself an act of resistance and a protest against systemic oppression (Dixon-Payne, 2022; Malcom et al., 1976; Ong et al., 2011). Black women and girls deserve frameworks that are created with them in mind. For example, Black Feminist Thought (BFT) is a social construction that redefines the significance of Black women's experiences from the viewpoint of Black women (Collins, 2022; Dixon-Payne, 2022). BFT understands the uniqueness and diversity of Black women's intersecting identities, while collectively honoring their experiences (Collins, 2022; Dixon-Payne, 2022; Ong et al., 2011). BFT can be used to reaffirm Black girls and women's voices and empower them to persist in STEM education.

Women in STEM disciplines continuously battle between their low expectancy of succeeding in STEM and the high value that STEM success provides (Crisp et al., 2009; Marsh et al., 2019). When women of color talk about themselves as science students, they often focus on experiences when they felt overlooked, neglected, or discriminated against (Carlone & Johnson, 2007). Black women significantly report having to prove themselves over and over again because their successes are downplayed and their expertise is questioned (Williams, 2015;

Zamudio et al., 2011). Black women also walk a tightrope between being seen as too feminine to be competent, and too masculine to be likable (Williams, 2015). Some women in science receive backlash for speaking their minds or being decisive. Bias against Black women, including their perceptions of bias against them, can drive them out of STEM careers (Singleton, 2015; Williams, 2015). Multiplying Black girls' low expectancy of success with Black women's low perception of STEM success results in a low motivation to persist in the STEM pipeline. BFT is one way to empower Black women and girls' STEM identity, another way is through informal education.

Informal Education

Large amounts of research suggests that Black girls who engage in science outside of the traditional school setting are able to construct successful STEM identities more easily (Brickhouse et al., 2000; King & Pringle, 2018; Morton & Smith-Mutegi, 2022; Pinkard et al., 2017; Pinkard et al., 2020; Wade-Jaimes et al., 2021). Including informal STEM learning can offer a more holistic educational approach for Black girls than only considering traditional school settings (Bevan et al., 2013; King & Pringle, 2018; Morton & Smith-Mutegi, 2022). Examples of informal education in this study included afterschool programs, museums, weekend workshops, and camps that can bridge diverse stakeholders as well as be sights for STEM learning (Bevan et al., 2013). Informal learning can serve as counterspaces for Black girls to reflect on their lived experiences, form new understandings, and reimagine their traditional STEM learning environments (King & Pringle, 2018; Wade-Jaimes et al., 2021). Traditional schools focus much of their efforts on teaching the students while highlighting an increased pressure on student test scores (Fenichel & Schweingruber, 2010). On the other hand, informal learning settings often place greater emphasis and assessment on student engagement and interest

(Fenichel & Schweingruber, 2010). When given this alternative to formal learning and an opportunity to share their counterstories, Black girls can become more confident in their STEM identity through informal learning (King & Pringle, 2019).

Even with this proven research, informal STEM learning still needs to include participation from communities that are historically underrepresented (Bevan et al., 2010). There need to be more theories and resources created to foster more equitable, culturally responsive STEM learning experiences for diverse students (King & Pringle, 2019). Science experiences need an intentional strategy to provide access and inclusion to more children as a resource in formal and informal education (Bevan et al., 2010). This study will contribute to the very limited collection of theories to expand informal STEM learning as a way to empower Black girls' STEM identity.

Making connections between the school curriculum and the students' lived experiences motivates science learning and empowers underrepresented communities (Calabrese-Barton & Berchini, 2013). The role of family, community, and mentors can increase persistence for Black students. This is because the students are accustomed to receiving encouragement and reminders of their academic success from these supporters (Burt et al., 2019). Educational leaders should take into account the racial and cultural perspectives of underrepresented student populations to shape institutional environments, programs, and practices that ultimately impact the students' experiences and outcomes (Museus, 2013). It is also important to have community support that builds relationships among teachers, classmates, and families. Having individual and collective resilience improves a sense of belonging that allows Black girls to succeed in their sometimes-hostile learning environments (Joseph et al., 2017). Creating opportunities for these students to

embrace their intersectionality while solving challenges provides them access to innovative career options (Birney & McNamara, 2019).

Informal STEM learning should not be simply viewed as a supplement to traditional learning (Bevan et al., 2013), which implies that new analysis and assessment should be used in informal learning instead of blindly adopting the same assessments from school settings. As STEM learning moves outside of the traditional school setting - and modifies subjects and textbooks that have engineering or science labels - it becomes more complex and more important to understand what counts as STEM learning and how to assess its student impact (Bevan et al., 2013). In addition to identifying new ways of learning, informal STEM learning can be a context to document learners' development and rethink formal schools (Bevan et al., 2013). Thus, this study on informal STEM learning will not be used in isolation, but it actually expands research and understanding about holistic student learning and educational leadership.

In summary, informal STEM educators and educational leaders need to intentionally consider their contribution *to* Black girls. The practitioners of informal STEM learning can place the focus on student engagement instead of standardized test scores. The adult practitioners can be the ones who create the theories and resources for more equitable, culturally responsive STEM learning experiences for underrepresented students. Informal education practitioners can collaborate with family, community, and mentors to aid in their students' STEM persistence. The professionals can also guide students to embrace their intersectionality and create their own career paths. Informal STEM educators and educational leaders can capitalize on their connection to traditional school learning, and contribute to the entire system of learning that students experience (Fenichel & Schweingruber, 2010). Now, instead of the informal STEM

educators and educational leaders working separately, this study was a unique opportunity for them to collaborate with each other to advance informal STEM learning for Black girls.

A Solution: Research-Based Strategies for Black Girls in STEM Learning

There are research-based programs that are directed at girls of color that have been successful to combat racism and empower their STEM identity. All of the programs go beyond the individual student to explore societal forces pushing the narrative of Black girls as non-scientists (Wade-Jaimes & Schwartz, 2018). The programs attempt to counteract detrimental strategies of their educators that may sometimes include controlling what Black girls do, say, or how they simply exist (Wade-Jaimes & Schwartz, 2018) by encouraging them to be quieter and more passive to be considered good students (Fordham, 1993). At times, the adults in charge of student learning can limit Black girls' participation in science along with withholding affirming discourses that would support their STEM learning and development (Wade-Jaimes & Schwartz, 2018). Successful informal STEM programs with Black girls have done quite the opposite to affirm their intersectionality by including them *within* the course design, including role models in their learning curriculum, and empowering their STEM identity. Four examples of informal STEM programs for Black girls that are featured in this PLC's design are: *COMPUGIRLS* (Scott & White, 2013), *I AM STEM* (King & Pringle, 2018), *Girls STEM Institute (*Morton & Smith-Mutegi, 2022), and *Digital Youth Divas* (Pinkard et al., 2020). All of these programs provided girls with the opportunity to learn about STEM fields, get hands-on experience, and connect with female STEM professionals. Programs like these intentionally disrupted the racialized and gendered disparities facing many Black girls in STEM and enhanced their STEM identity by encouraging their STEM communication and participation (King & Pringle, 2018; Morton & Smith-Mutegi, 2022; Pinkard et al., 2017).

Research suggests that instead of expecting students to memorize and recite a static set of science facts, informal STEM educators should present science in a way where students can use their own creativity to make sense of data and learn from it (Wade-Jaimes & Schwartz, 2018). Specifically, STEM communities for girls are needed all along the educational journey so that girls have a space to access narratives and create counterstories of successful women in STEM (King & Pringle, 2019; Morton, 2022; Pinkard et al., 2017). When Black girls are given the opportunity to work at their own pace, create what *they* imagine, share and learn with others, and engage with a variety of STEM concepts and practices, they can increase their perception and connection to STEM (Pinkard et al., 2017; Scott & White, 2013). For example, the framework for the Digital Youth Divas program connected the existing interests of their girl participants to STEM. The framework included a narrative storyline, project-based learning curriculum, an online network, and adult mentors (Pinkard et al., 2017). Included as empirical research for this study's PLC participants to read, these programs are helping to close the gender gap in STEM and prepare Black girls for careers in these fields.

Networking within the informal STEM *community* itself may be the hub of the support system for Black girls in informal STEM learning (Bevan et al., 2010; Pinkard, 2019). This *connective tissue* focuses more on the relationship between education spaces, and how they can be connected instead of relying on each individual student to make their own connections for learning opportunities (Birney & McNamara, 2019; Pinkard, 2019). Many minoritized students and their families are responsible for the entire educational journey including desiring STEM programming, finding it, registering, enrolling, attending, and then continuing to the next program (Pinkard, 2019). While parents significantly influence a child's early interest in STEM, they are just one piece of the puzzle in fostering their child's STEM identity (McPherson, 2014).

Education practitioners could offload some of this burden by creating strategies to reduce the barriers that can limit STEM education providers from serving the greatest number of students possible (King & Pringle, 2019; Pinkard, 2019). A healthy learning *ecosystem* knows the learning opportunities within the community, and has mapped out multiple pathways for students to explore them (Pinkard, 2019).

All of this expertise from research on encouraging Black girls to participate in informal STEM learning begs the question: How do informal STEM practitioners of Black girls *learn* to pursue such work together?

A Complementary Solution: Professional Learning Communities

A Professional Learning Community (PLC) for educators and educational leaders complements efforts that strive to increase STEM exposure, access, and identity development for students. A large body of research has proven that PLCs positively impact student achievement (DuFour, 2004; Fulton & Britton, 2011; Hord, 2004; Rhoulac Smith et al., 2008). A PLC values a strong and consistent focus on professional learning to improve student learning (DuFour, 2004). There are five critical elements for a strong professional community: reflective dialogue, focus on student learning, interaction among teacher colleagues, collaboration, and shared values and norms (Kruse et al., 1994). PLCs encourage a collaborative culture of shared ownership, responsibility, and success among teachers and for each student (DuFour, 2004). Part of the collaborative culture is grown through reflective dialogue, which includes having conversations about what helps students learn best (Buttram & Farley-Ripple, 2016; Kruse et al., 1994). Furthermore, successful learning communities result in more effective STEM teaching and positive student achievement (Fulton & Britton, 2011; Heimlich et al., 2021). Therefore, this

study sought to combine empirical research and reflective dialogue within the context of a temporary PLC to advance informal STEM learning.

In addition to a PLC, there are other types of learning communities. In a Community of Practice (CoP), experts share knowledge, practices, goals, and outcomes of a shared field such as STEM (Townley, 2020; Wenger et al., 2002). A CoP also effectively enhances educator learning (Cox, 2006; Eib & Miller, 2006). Research suggests that seven design principles allow the members of the CoP to meet specific goals (Kezar et al., 2017). For example, the first principle is to design the community to evolve naturally, which allows the CoP to shift its focus as members come and go. The other design principles focus on open dialogue, flexible participation, individual relationships, community values, brainstorming, and a regular rhythm for activities and events. While the design principles are important, the philosophy of the CoP and the personal interactions that engage its members are what make a CoP effective (Kezar et al., 2017; Townley, 2020). However, PLCs have a specific goal to positively impact student learning and outcomes (Townley, 2020). Thus, a PLC model was used in this study because of its collaborative culture where participants have the agency to act on the theories that they learn.

In summary, research suggests that the various types of learning communities are effective when there is strong leadership support, self-directed reflection, and shared values and goals (Fulton & Britton, 2011; Townley, 2020; Leithwood et al., 2008; Young-Wallace et al., 2020). Communities devoted to underrepresented students in STEM use the collective leadership of educational leaders, educators, and community stakeholders to create a culture of success (Fulton & Britton, 2011; Malcom et al., 1976; McClafferty et al., 2009). This section of the literature review highlights some of the key components of PLCs where its members can

positively impact student achievement and strategically plan for the successful recruitment, education, and retention of Black girls in STEM (Alfred et al., 2019).

Professional Learning

Similar to STEM learning for the students, *Professional Learning* is when adult learners take in data, organize the information, make meaning of the data, and then act on their findings (Heimlich et al., 2021). Professional learning happens through interactions with others and real-world applications (Townley, 2020; Heimlich et al., 2021). This learning happens outside of the classroom or the theoretical textbook (Townley, 2020). Research also suggests the importance of sense-making activities in active learning where educators can model promising practices and try them out (Darling-Hammond et al., 2017). Furthermore, research shows that adult learning is influenced by the nature of the learners, the content to be learned, and the culture (context) of where the learning happens (Heimlich et al., 2021). Additionally, research suggests that educators who use research-based practices in their own learning have higher levels of student achievement (ACER, 2019). In this study's PLC, the participants explored how to connect existing knowledge to research-based practices for improved student outcomes (Townley, 2020) by reading empirical research, then providing recommendations of the content knowledge that they would like to learn and the pedagogical design of a PLC context.

Research shows that professional development with a focus on increasing *educator* self-confidence and self-efficacy in STEM can increase underrepresented students' interest in STEM (Birney & McNamara, 2019). Educators are able to practice and think for themselves if they adjust to a collaborative teaching and learning design (Krainara & Chatmaneerungcharoen, 2019). For example, building a learning community where STEM teachers use research-based methods to learn more STEM concepts and collaboratively designs STEM lessons, improves

their *own* teaching practices. that (Krainara & Chatmaneerungcharoen, 2019). Also, research suggests that increasing teacher efficacy improves their STEM teaching and their student participation (Fulton & Britton, 2011; Krainara & Chatmaneerungcharoen, 2019).

An exemplary model to prepare culturally responsive teachers for school-university partnerships and teacher education is Professional Development School (PDS) (Chen et al., 2017; Jiang et al., 2016). Within professional learning, teachers are committed to reflection as a group activity where they can discuss ideas and teaching practices (ACER, 2019; Darling-Hammond et al., 2017), which was part of this study's focus groups. Partnerships between universities and schools can be used to improve teacher preparation and professional development (Chen et al., 2017; Jiang et al., 2016). Therefore, the focus groups for this study were modeled after a university curriculum where students read empirical research, came together for discussions, then reflected on their learning.

PLCs can also exist across virtual, online, and remote networks where members may never meet in person. Technology can also support the goals of the learning community in innovative ways. Some examples include file-sharing of student work, observing live-streamed or previously recorded lessons, and commenting on discussion boards (Fulton & Britton, 2011). Therefore, the success of PLCs is not limited by space and time, making them accessible anyplace and anytime (Fulton & Britton, 2011). However, engagement in online communities is often self-initiated and self-selected where members can determine their own level of participation (Fulton & Britton, 2011). Also, because members of virtual PLCs do not share common schools or students, they can often feature more discussion of pedagogy, its application, and collaborative materials (Fulton et al., 2010; Fulton & Britton, 2011). Although this design is not ideal for all education practitioners, there is still value in breaking teacher isolation to confer,

collaborate, and share (Fulton & Britton, 2011). Thus, this study used technology to support virtual, PLC focus group meetings.

Collective Leadership of Informal STEM Practitioners

As an alternative to formal education, research suggests PLCs can also support non-traditional learning environments such as informal education spaces (Heimlich et al., 2021; Swanson, 2018; Tran et al., 2013). This research sought to include the practitioners of youth informal STEM education, both educators and educational program leaders. Typically known as the program administrator or a non-profit organization's Executive Director, the educational leader is like the CEO of a company who provides vision and leadership (Biddle et al., 2018). They are strong, thoughtful leaders who overtly support project goals with a clear chain of command, and are essential to facilitate an organization's cultural change (McClafferty et al., 2009). This study has chosen to focus on both supportive **educational leaders** – leaders of informal STEM programs, and key **educators** who directly instruct students within those programs – because they are the ones who set the culture for reform, and shift the culture to emphasize teaching and learning (Buttram & Farley-Ripple, 2016).

Educational leaders support students through their staff and programming (Biddle et al., 2018). Above all, the educational leader must be strongly student-centered (Buttram & Farley-Ripple, 2016; Hargreaves, 2003). Educational leaders work countless hours and have an ethical responsibility to support children's education, children's futures, and the future of society (Biddle et al., 2018). Although focused on the students, educational leaders have a measurable, but indirect effect on student achievement (Biddle et al., 2018; Buttram & Farley-Ripple, 2016; Leithwood et al., 2008). Educational leaders are both advocates for student learning, and facilitators of adult learning for their organization's educators.

Even when given the power to direct their own professional learning and development, educators want the educational leaders' support, guidance, and resources (Fulton & Britton, 2011). These benefits from the educational leader positively influence educator motivation, commitment, and beliefs (Leithwood et al., 2008). Relationships can be formed between educational leaders and educators through mentoring, peer-to-peer learning, and brainstorming solutions for STEM education reform (Hargreaves, 2003). This same collective leadership took place in this study's PLC where participants were able to both lead and learn (Hord, 2004).

Moving beyond education practitioners' roles and paradigms, it was important for participants to actively support collaboration in the learning community (Buttram & Farley-Ripple, 2016). Research suggests that strong PLCs that work collaboratively can lead to effective student learning and achievement (Darling-Hammond et al., 2017). Also, collaborative teams that are consistently seeking ways to implement research-based decisions is one indicator that a group is shifting into a PLC (Eaker et al., 2009; Fulton & Britton, 2011). Thus, it was important to engage educators and educational leaders in reading empirical research and collaboratively discussing their ideas within this study. This study sought to reveal further implications for collaboration within PLCs including their ideal learning modality, the people who should be involved, and the research that is discussed to advance STEM learning for Black girls.

Shared Values and Goals of PLC Members

Research on PLCs suggests that as members of PLCs collaborate, a shared vision of worthwhile student learning can emerge (Fulton & Britton, 2011). Educational leaders of effective learning communities communicate and support the goals of the STEM educators whom they lead (Fulton & Britton, 2011). When education practitioners share an aligned culture and communicate effectively can motive students to pursue STEM disciplines (Kirst & Venezia,

2004). One way to ensure accountability in this study's PLC was to evaluate learning progress with assessments and data along the way through questionnaires (DuFour, 2004; Townley, 2020; Hargreaves, 2003; Hord, 2004), which participants appreciated.

Research suggests that PLCs are best designed when they reflect the diversity of its members and embrace the expertise of the members who run them (Kezar et al., 2017). Educators have diverse lived experiences, and sometimes prior careers that contribute to their work (Hargreaves, 2003). Linking their lived experience encourages educators to include themselves in their teaching practices. Among the many collaborative practices of these teachers, reflective dialogue is most encouraged (Buttram & Farley-Ripple, 2016; Townley, 2020; Hord, 2004; Kruse et al., 1994), and also used in this study's PLC.

It is noteworthy that there is an increased demand for anti-racist professional development (Pollock & Matschiner, 2024), which was a request shared among participants of this study. Research suggests that improving STEM educators and their instructional methods to be more *culturally responsive* is a way to increase STEM interest among women and underrepresented students (Birney & McNamara, 2019; Fenichel & Schweingruber, 2010). In addition to understanding the subject matter, such educators understand their students and the way they learn. They use this knowledge to encourage students to explore STEM-related career options (Birney & McNamara, 2019). Increasing the number and quality of STEM educators helps students think critically, creatively, and collaboratively (Burrows & Slater, 2015). If reform in STEM education is to take place, it has to begin with the educators (Hodge et al., 2020). By increasing participation in PLCs, educators commit time and energy to improve themselves on behalf of their students. Thus, PLC members in this study included informal STEM practitioners who prioritize culturally responsive education.

Conclusion

It is vital to recruit, retain, and develop effective education practitioners for the success of marginalized students (Khalifa et al., 2016). Research shows that Black students are often culturally disconnected from their non-Black teachers, their teaching styles, as well as their interactions with them (Young-Wallace et al., 2020). Research also suggests that the capacity to better support students can grow exponentially when diverse education practitioners come together in a shared learning experience focused *on* supporting students better (Kruse et al., 1994). With collaboration, educators and educational leaders can create organized and synchronized STEM education efforts. Their collective leadership could enable and support more effective teaching and learning and create a culture of educational success for Black girls in STEM (Fulton & Britton, 2011) with long-lasting sustainable improvements (Hargreaves, 2003).

Since education reform is a large undertaking, solely developing individual educators or isolated departments will have minimal impact. Leveraging learning communities in both formal and informal ways can impact engagement, retention, and real-world preparation in STEM (Townley, 2020; Kezar et al., 2017). Furthermore, collaborations originating in STEM education may expand into larger reform initiatives across all education disciplines (McClafferty et al., 2009). Thus, this dissertation set forth to engage both informal STEM educators and educational leaders to collaboratively participate in the design of a PLC that can help advance informal STEM learning for Black girls.

CHAPTER 3: METHODOLOGY

Introduction

This participatory action research (PAR) study used a qualitative approach to gain insight into the perceptions of a group of practitioners of informal STEM learning on the professional learning they themselves need when a) presented with research, b) led through focus group dialogues and reflections, and c) interviewed about how best to support their own work with Black girls. It was essential to invite the practitioners of informal STEM education to participate in this research so that they *themselves* could determine the action needed to support them in improving the field of education. A PAR research design was used to build relationships between practitioners, turn their practice into action (Kemmis et al., 2014), and empower the participants to attempt social change (Creswell & Guetterman, 2018).

The San Diego STEM Ecosystem was the primary source to find research participants. Individuals interested in participating in this study completed a questionnaire about their experience in informal STEM learning and scheduled an initial 40-minute interview to discuss their questionnaire and their commitment to the research. Based on their relevant lived experiences and availability to attend all three focus group sessions, 14 practitioners of informal STEM learning were invited to participate in a temporary PLC. The research participants were introduced to empirical research on Black girls in STEM by reading at least three pre-selected bodies of work to be discussed across three meetings. Each PLC meeting was simultaneously held as a focus group, followed by a reflection questionnaire. Then, participants were interviewed about the content knowledge and pedagogical design of a PLC to better support Black girls in STEM. The following sections explain the research design, context of the study, participant selection, the plan for focus group meetings, descriptions of data to be collected, the

thematic analytic approach used to answer the research questions, and potential limitations of the study.

Research Design

This study used a qualitative PAR design to study how informal STEM practitioners made sense of empirical data and their recommendations on designing a PLC to support Black girls in STEM. Research suggests that the aim of action research is to not only improve participants' understanding of their practice and the rationale behind their actions (Kemmis et al., 2014), but also to engage them in improving the education field (Creswell & Guetterman, 2018). In this study, the data source was the participants themselves, and their continually growing perspective as they self-consciously participated in inquiry and action designed to improve their own work and make recommendations on design supports for that work in the form of an ideal PLC. The conversations held in this study sought to develop how participants think, what they do, and how they relate within this study and beyond (Kemmis et al., 2014). This study focused on how informal STEM educational leaders make sense of empirical research in their own work, and relate it to the ongoing professional learning they need to do to better serve Black girls.

Specifically, this study used *participatory* action research methods (Creswell & Guetterman, 2018; Kemmis et al., 2014). Action research is a way of generating research about a social system while simultaneously taking action to change that system; in *participatory* action research, participants collaborate even more with the researcher in everything from research design to analysis of data. The participatory nature means that the participants sought to develop a community that will turn their practice into action. In this study, the community not only built relationships between the research participants, but also built relationships between practitioners who are collectively responsible for students as professional educators (Kemmis et al., 2014).

Since this was a community-based project, it was essential to invite the practitioners of informal STEM education to participate and determine the actions needed to support them.

Most importantly, research suggests that PAR aims to be emancipatory by improving and empowering the participants and their educational organizations (Creswell & Guetterman, 2018). PAR challenges inequality and focuses on including participants to attempt social change (Creswell & Guetterman, 2018). It takes collaboration between the researcher and the participants to understand a problematic situation and change it. This way, participants sought to break free from the irrational and unjust structures that have limited their own development (Creswell & Guetterman, 2018). Connecting these points, participants in this study had the opportunity to understand and empower themselves within education as an opportunity to improve the greater field of education, especially for Black girls in STEM.

Setting and context: STEM Ecosystem

The National Science Foundation (NSF) Advancing Informal STEM Learning (AISL) program is unique in its focus on funding research and initiatives that explore how people learn STEM outside of traditional schools. Their goal is to not only advance understanding of informal STEM learning experiences, but also to ensure these experiences promote lifelong learning, equity, and a sense of belonging in STEM fields for historically underserved communities (National Science Foundation, 2022). Also, the United States Congress created Bill S.3636 - Strengthening STEM Ecosystems Act "to establish the National Science Foundation a program to award STEM ecosystem grants" that includes "informal educators, informal STEM organizations, community-led and community-based research organizations" (Congressional Research Service, 2022). These awards also include outreach to increase the exposure and participation of women and underrepresented minorities in STEM fields. This research study

aligned with the AISL and Strengthening STEM Ecosystems Act goals to develop collaborations within the context of the San Diego STEM Ecosystem among people who seek to advance informal STEM learning for Black girls.

This study took place was initiated in the San Diego STEM Ecosystem. The San Diego region contains a self-named "STEM Ecosystem" of diverse stakeholders committed to cultivating and sustaining a robust and equitable STEM community (STEM Funders Network, 2020). This community of people, convenes three times a year, led by a local science museum has provided "opportunities for rich and effective lifelong STEM experiences in- and out-of-school for all learners of all ages" (STEM Funders Network, 2020). The San Diego STEM Ecosystem has participants in neighborhood networks and working groups, which meet 12 times a year. The mission of the working groups is to build county-wide networks primed for collective action initiatives. Specifically, the Innovation in K-12 working group was the starting point to invite research participants to this study. Innovation in K-12 has goals that include: connecting regional networks of education partners, increasing K-12 STEM innovation and opportunities, identifying and promoting model STEM programs, and increasing student STEM identity. This study included 14 research participants who were currently practitioners of informal STEM programming for children in grades K-12 in San Diego County.

Participants and sample

A background questionnaire and initial interview guided purposeful sampling of 17 applicants to prioritize San Diego-based informal STEM educators and educational leaders who could participate in all three focus groups. Purposeful sampling allowed the researcher to discover, understand, and gain insight from participants who will provide rich accounts of the phenomena to be studied (Merriam & Tisdell, 2016). The 14 selected participants provided

thorough research-based recommendations on designing a PLC for informal STEM leaders to support Black girls in STEM.

Although research suggests that informal STEM programs can function as counterspaces to support Black girls' science identity (King & Pringle, 2019; Wade-Jaimes et al., 2021), the reality is that informal STEM programs often *still* have underrepresentation or no representation of Black girls. For this reason, the research participants and their organizations were not required to be serving Black girls at the time of this study. However, this research could encourage them to expand representation in their programs across these demographics. Also, Black girls were not research participants in this study because the interest of this research lies in the conversations of the informal STEM practitioners who design and influence the learning experience for Black girls. Nevertheless, Black girls' voices and experiences were reflected in the empirical research that the participants read.

In this study, participants and their organizations were identified by pseudonyms, as shown in Table 1 below. Of the 14 participants, five of them were Black women; their pseudonyms are marked with an asterisk (*). Those not starred included White Women, Women of Color, Black men, a Man of Color and a White Man. The table also includes how they self-identified as an Educator or Educational Leader, and their attendance at each focus group meeting indicating if they attended the first or second session.

Table 1: Participants and Attendance

Pseudonym	Role	Initial Interview	Focus Group 1	Focus Group 2	Focus Group 3	Final Interview
AJ*	Educator	Y	1	1	1	Y
Khalil	Educator	Y	1	1	1	Y
Mina*	Leader+Educator	Y	2	2	2	Y
Red*	Leader+Educator	Y	2	1	1	Y
Charles	Leader+Educator	Y	1	2	2	Y
June	Leader+Educator	Y	2	2	2	Y
Square*	Leader	Y	1	2	2	Y
Laila	Leader	Y	1	1	1	Y
Coco	Leader	Y	2	2	2	Y
Victor	Leader	Y	2	2	1	Y
Daniel	Leader	Y	2	2	2	Y
Matilda	Leader	Y	2	2		Y
Moxie*	Leader	Y	2	2		Y
Joy	Leader	Y	2		1	Y

Data Collection

After presenting an abbreviated version of this dissertation proposal to the San Diego STEM Ecosystem, and receiving Institutional Review Board (IRB) approval, interested informal STEM practitioners were invited to participate in a "temporary PLC" for data collection. This PLC took place online due to its increased availability and flexibility for the participants (Fulton & Britton, 2011). Data Collection utilized Zoom web conferencing platform, and an e-learning course on a learning management system platform with a sample view shown below in Figure 2. Primary data collection for this research study included a background questionnaire, audio recording of two semi-structured interviews (before and after the focus groups) with each of the

participants during the study, an audio recording of all three online focus groups, and an electronically submitted reflection questionnaire after each focus group.

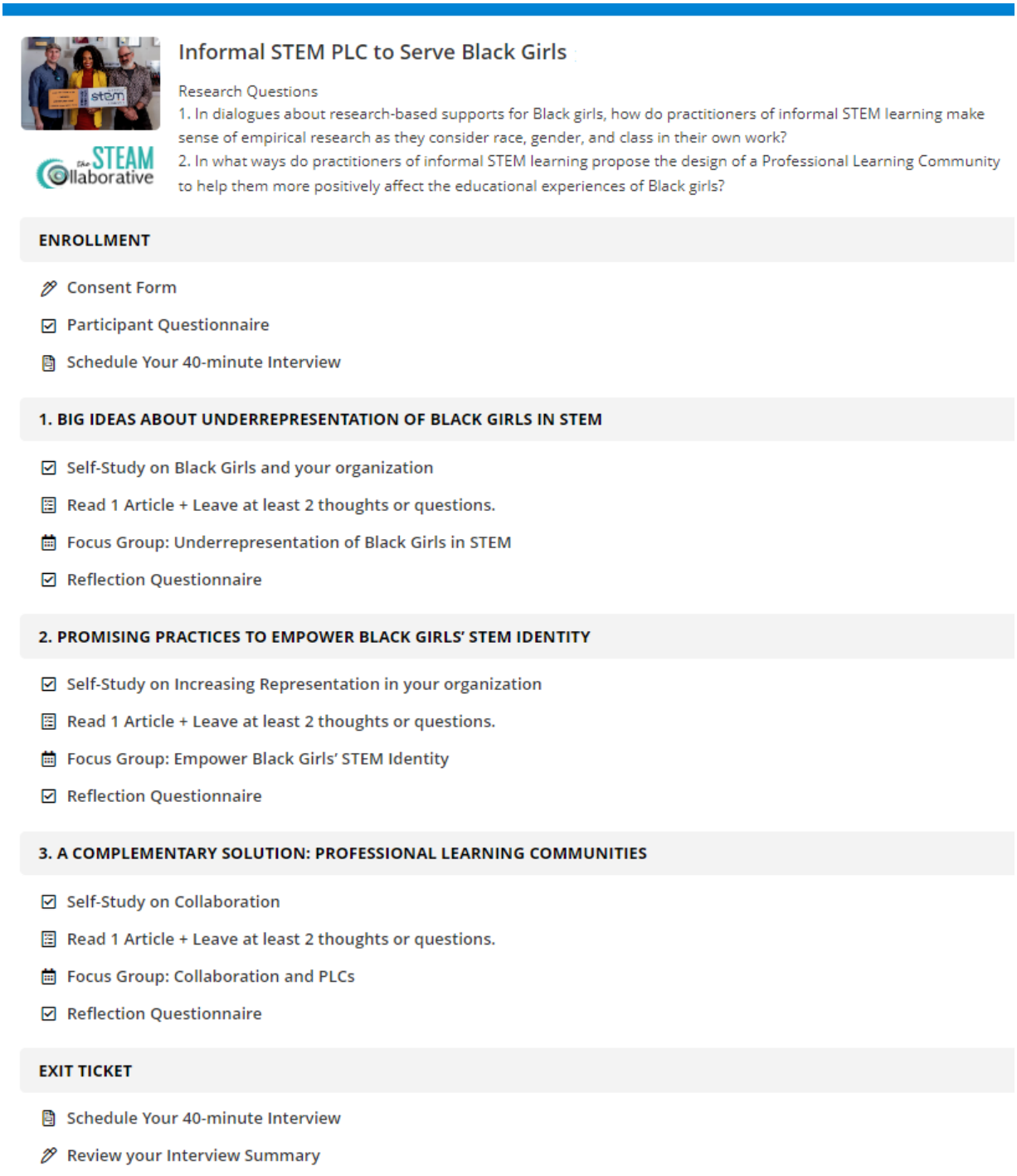

Figure 2: Course Outline on e-Learning Platform

Participants were asked to complete a consent form and an online background questionnaire, and to schedule an initial interview with the researcher. This initial 40-minute individual interview (Appendix A) sought to understand applicants' current interests as it pertains to professional learning, collaboration, and advancing informal STEM learning for Black girls. The researcher engaged participants in three focus groups that functioned as PLC meetings for this dissertation research and was, with participants' permission, recorded and transcribed. Prior to each focus group, participants read at least one pre-selected body of empirical research as a prompt for a deeper dialogue about the full range of support needed to advance informal STEM learning for Black Girls. Participants completed a reflection questionnaire after each focus group that was submitted electronically. Each participant scheduled a final 40-minute individual interview as an attempt to understand each informal STEM educator and educational leader's recommendations about their ideal PLC. An overview of the Meetings and timeline is shown below in Table 2.

Table 2: Timeline of PLC Meetings

Meeting	Date	Description	Topic
0	March 2023	Seminar + Interest Sign-up	Dissertation Proposal Presentation: Introduction, Participants, Framework, Research Topic
1	Summer 2023	Consent + Participant Questionnaire + Initial Individual Interview	Participants' lived experience and PLC praxis and process
2	September 2023	Pre-Reading + Focus Group + Reflection Questionnaire	Big Ideas about the Underrepresentation of Black Girls in STEM
3	October 2023	Pre-Reading + Focus Group + Reflection Questionnaire	Promising Practices to Empower Black Girls' STEM Identity
4	November 2023	Pre-Reading + Focus Group + Reflection Questionnaire	Collaboration and Professional Learning Communities
5	December 2023	Final Individual Interviews	Participants' recommendations on PLC praxis and process

Meeting 0 was a seminar held to introduce the research and the study to prospective research participants. An abbreviated dissertation proposal was presented to the San Diego STEM Ecosystem during a local conference. The seminar was a 15-minute oral presentation with a discussion to answer any initial questions. Following the presentation, interested informal STEM practitioners were asked to submit their contact information. After IRB approval from the University of California San Diego, interested contacts were invited to register as research participants and schedule their initial interview. Meeting 1 consisted of each participant providing signed research consent, and the researcher began data collection during their initial interview. The researcher gathered preliminary data from participants in the form of a brief

online questionnaire describing their professional background, current programming background, and professional learning needs, as shown in Appendix A. The researcher conducted an initial 40-minute interview with each participant about their knowledge and experiences of PLCs, and advancing informal STEM learning for Black girls in their work. The participants were also asked about the number of years they have been leading STEM learning programs or organizations, the number of years they have been part of a PLC (i.e., the San Diego STEM Ecosystem), the grades of the students they serve, and their availability to meet for the focus groups. Based on their responses, the subsequent meetings were planned to fit the schedule of the participants and the availability of the researcher, which resulted in each of the three focus groups occurring over two sessions held on Tuesday evenings and Wednesday mornings.

Research suggests that PLCs are effective when there is strong leadership support, self-directed reflection, and shared values and goals (Fulton & Britton, 2011; Townley, 2020; Leithwood et al., 2008; Young-Wallace et al., 2020). Because of this, Meetings 2, 3, and 4 were focus groups that allowed participants to experience a temporary PLC. That is, the participants met as a PLC, and the conversations were audio recorded for research purposes, then transcribed via Rev.com. To encourage participation in the study, prior to each focus group, the researcher assigned each participant a self-study assignment in Appendix B. Participants had the option to submit their initial responses to the self-study assignment or discuss them during their introduction in the PLC meetings. All participants were assured that beyond the conversation of the group itself, which involved all participants, data transcripts and findings were confidential for public research sharing. This temporary PLC format was selected in an attempt to have participants make a more informed recommendation about the pedagogical design of a future PLC.

Prior to each of the three focus group meetings, participants were requested to read at least one body of work from the list in Appendix C, and on the e-learning platform asked to name the article(s) that they read, leave at least two thoughts or questions about the reading, and the opportunity to document initial responses to the focus group prompts, which could be accessed during the focus groups. Each one-hour focus group was facilitated by the researcher. The researcher presented a brief recap of the meeting's assigned readings, then facilitated a dialogue using the focus group discussion prompts in Appendix C. In this study, the focus groups gave participants the opportunity to have collaborative conversations for their professional development (Heimlich et al., 2021). Their focus group dialogue and reflection questionnaire responses helped to answer the first research question about how informal STEM practitioners make sense of the empirical research about Black girls in their own work.

Immediately following the 1-hour focus group, 30 minutes was reserved for each participant to complete the reflection questionnaire via the e-learning platform. The intent was to encourage participation in a convenient way for participants. The reflection questionnaire prompts shown in Appendix D asked participants specifically about their praxis of implementing solutions to advance informal STEM learning for Black girls in their own work, and their own process of professional learning. It was also an opportunity to understand how important the reading itself was in the learning process and to understand if participants arrive at the same conclusions when they have access to the same information (DuFour et al., 2016).

For Meeting 5, all participants signed up for a convenient time to be individually interviewed by the researcher via Zoom. According to research, semi-structured interviews are the most used interview form in qualitative research (Ravitch & Carl, 2020). These semi-structured interviews asked specific questions to all participants and tailored follow-up questions

depending on individual participant responses (Ravitch & Carl, 2020). Using the questions shown in Appendix E, these virtual, semi-structured interviews took about 40-60 minutes each. Ultimately, the individual interviews most directly answered the second research question, which asked specifically about the participants' recommendations on *content knowledge* and the *pedagogical design* of a PLC. Also, each interview was recorded and transcribed via Fireflies.ai. For all 14 participants, the researcher wrote a post-interview summary, which was member-checked by each participant. Next, I discuss how thematic analysis was performed on the post-interview summaries and data that was submitted using the e-learning platform.

Data Analysis - Thematic Analysis

The data analysis method for this research was thematic analysis using the software MAXQDA. Thematic analysis was the method used to examine participants' perspectives and notice relationships, similarities, and differences in data (Braun & Clarke, 2006; Ravitch & Carl, 2020). It is also a method that identifies and generates unanticipated insights from the data (Braun & Clarke, 2006). The six steps of thematic analysis are: to become familiar with the data, generate initial codes, search for themes, review themes, define themes, and write them up (Braun & Clarke, 2006). Each participant went through their own individual PLC experience with varied responses as reflected in the pre- and post- interviews. Thematic analysis was useful to identify and organize the varied data into themes, such as "Silos to Connections", and "Peer-led Professional Development". Participants' perspectives captured from focus group discussions provided additional data. Focus group transcriptions were checked for accuracy following each session and coded by the author to classify and interpret the findings to draw conclusions.

This qualitative study also tapped Critical Race Feminism (CRF) as one guide to help analyze the research data. As the facilitator of the focus groups, the researcher tapped CRF as a

theoretical framework to highlight points made in the focus group dialogue, reflections, and interviews, but the researcher did not impose CRF on the participants or the data analysis. The researcher used CRF to help identify, but not impose, themes in the data (like "Recruit Black Girls", and "Recognize and Address Stereotypes"). These themes helped the researcher to explore and understand how informal STEM educators and educational leaders might help improve the lives of girls of color who face multiple forms of discrimination based on race, gender, class, and how these factors interact within the education system (Dixon-Payne, 2022). Additionally, CRF was used as a multidisciplinary approach that focuses on both theory and praxis (Wing, 2003). For example, conversations and data analysis explored how informal STEM learning opportunities have been used as a *counterspaces* to emphasize culturally relevant and gendered practices instead of replicating the racist structures that Black girls experience in traditional schools (Dixon-Payne, 2022). The researcher allowed participants to make understandings in their own way, and make recommendations in their own words. Yet, the researcher remained attentive to some of the pertinent theories of CRF, such as the need to explore women of color's experiences from their perspective, and to analyze systemic discrimination against them due to their intersections of race, class, and gender.

Following each of the three focus groups, the researcher documented theoretical and reflective thoughts in an analytic memo to self. Then, after reading the focus group reflection questionnaire responses, the researcher documented thoughts about potential codes/ themes. Coding is the process of segmenting and labeling text to form descriptors and broad themes in the data (Creswell, 2018). The focus group transcripts and reflections were coded by looking for patterns that emerged, especially as they pertained to CRF (i.e., essentialism when comments diverted away from Black girls to another demographic) and, more broadly, the research

questions of this study (i.e., evolving their thoughts through focus group dialogue). Transcript notetaking and analysis took place in MAXQDA, a password protected software. Although responses were widely distributed, thematic analysis both encouraged naming those differences in data and highlighted their relationships with one another. This part of the iterative and reflective process (Nowell et al., 2017) also pointed to questions that were asked during the final semi-structured virtual interview to ensure the research was critical and comprehensive. Finally, to triangulate different data collection modes, the semi-structured final interviews were transcribed using Fireflies.com transcription software, reviewed for accuracy, summarized by the researcher, member checked, and coded for any new themes that emerged in MAXQDA.

Issues of Validity, Reliability, and Trustworthiness of Data

Although each participant represented his or her respective organization, each participant brought their personal lived experiences and feedback into the conversations (Hargreaves, 2003). Additionally, each participant had a different experience during this study, taking the relevant parts of PLC activity and using them for their needs (Heimlich et al., 2021). Yet, one special advantage to using PAR is the encouragement to value the link between participants' life and work instead of ignoring the connection (Kemmis et al., 2014). Member checking and peer debriefing were also used throughout some of the thematic analysis phases as auditable evidence to support the trustworthiness of the study (Nowell et al., 2017). All participants reviewed their own final interview transcript and read the researcher's interview summary. Some participants provided amendments to enhance the fairness, relevance, and accuracy of how they were represented (Kemmis et al., 2014), and they all confirmed the final version of their interview summary.

PAR was also used because it welcomes varied roles of leadership ranging from those who work directly with students to outside consultants and organizations. To avoid injustice in the research process, the researcher blurred the understanding of participants' roles as both learners and leaders to treat all of their perspectives as meaningful (Kemmis et al., 2014) rather than distinguishing between educational leaders and educators. Additionally, to encourage open and honest conversation, each participant chose to use a pseudonym for their name and their organization to minimize the risk of identification.

Ethical Issues and Role of the Researcher

As the researcher, I must acknowledge my positionality in my current role as an informal STEM educational leader. I was a Black girl interested in STEM, and the only access I received to engineering education was through informal STEM learning with the Detroit Area Pre-College Engineering Program (DAPCEP). I went on to graduate in Aerospace Engineering with a minor in Mathematics. Five years into my engineering career, I started a company in informal STEM learning with the mission to exponentially increase equity in education. My vision is to own and run a STEM and Arts University. After a 10-year career in engineering, I quit my job to work as a consultant in informal STEM education. Also, because of my positionality, I am a trusted partner of the San Diego STEM Ecosystem and had direct access to the research participants.

I feel very strongly about collaboration, research, and professional learning. I have seen collaboration among informal STEM educational leaders lead to advancing STEM learning for Black girls. Within this study's PLC, I witnessed education practitioners move beyond subjective feelings and systemically-oppressive statistics, to put empirical research into action. It is my hope that this study's findings will lead to the design and formation of PLCs for my friends and colleagues in both formal and informal STEM learning. Ideally, their collaboration will help

mend the leaky STEM pipeline, and lead Black girls to become successful, innovative, and joyful Black women in STEM. I took care to let this excitement galvanize study participants, but did not lead the participants to my own presumptions. I truly wanted to know whether the PLC as designed supported participants' professional learning, and what they recommended for an ideal PLC design for them to support Black girls.

Limitations of the Study Design

The major limitation of the study is the small sample size of research participants from the larger STEM community. Their participation is voluntary, and based on their interest in professional learning and their experience with leading or teaching informal STEM learning. Although they did not represent the entire San Diego STEM Ecosystem, these participants are similar to the ones who will work to form a future PLC. To accommodate for attrition, 14 participants were recruited to this study, with at least four participants in each of the two sessions of the three focus group meetings. These participants were the ones who provided recommendations on the content knowledge and pedagogical design of a PLC to advance informal STEM learning for Black girls.

CHAPTER 4: DATA ANALYSIS - PART 1. EXPERIENCES WITH PROFESSIONAL LEARNING AND SOLUTIONS TO IMPROVE STUDENT OUTCOMES FOR BLACK GIRLS IN STEM

Introduction

This dissertation explores the ideal design of a Professional Learning Community (PLC) focused on advancing informal STEM (Science, Technology, Engineering, and Mathematics) learning opportunities for Black girls in San Diego, California. A total of 14 informal STEM practitioners participated in this study designed as a temporary PLC to better understand their experiences with professional learning within this design, and make more informed recommendations about their ideal PLC. To find out how to design a PLC to advance informal STEM learning for Black girls, the following two research questions guided data collection and analysis:

1. In dialogues about research-based supports for Black girls, how do practitioners of informal STEM learning make sense of empirical research as they consider race, gender, and class in their own work?
2. In what ways do practitioners of informal STEM learning propose the design of a Professional Learning Community to help them more positively affect the educational experiences of Black girls?

As featured here, Chapter 4 (Data Analysis - Part 1. Experiences with Professional Learning and Solutions to Empower Black Girls' Student Achievement) answers the first research question. First, it was important to understand the learning that took place for participants in this study intentionally focused on Black girls in informal STEM learning, and how this study's PLC design impacted informal STEM educators and educational leaders. The

design included reading empirical research, completing a self-study assignment, attending a monthly focus group, and completing a virtual reflection questionnaire at the conclusion of each focus group.

The focus group dialogue provided the most insight on how informal STEM practitioners made sense of empirical research as they learned within this temporary PLC – one key feature of this PLC's design. Participants read at least one pre-selected empirical research article as a prompt for each of the three PLC focus group meetings. In reacting to the pre-reading and focus group questions shown in Appendix C, participants shared their own *big ideas* about the underrepresentation of Black girls in STEM, along with *promising practices* and *quick wins* that they learned to empower Black girls in STEM. Chapter 4 also includes the benefits of the PLC described by the participants as well as their collective definition of a PLC based on their experience in this study's PLC.

As we will explore in more depth later, Chapter 5 (Data Analysis - Part 2. Ideal PLC Design to Advance Informal STEM Learning for Black Girls) answers the second research question. Participants envisioned their ideal PLC design going forward, and shared insights on a conceptual framework design of a PLC for themselves that answered the following questions: *What* knowledge and skills would enhance learning in a PLC?, *How* should the PLC members learn?, *Who* should be included in the PLC?, and *Why* is this a suitable Framework for a PLC in informal STEM education? We return to these recommendations in the following chapter; I now focus on participants' descriptions of their professional learning experiences with the design of this study's temporary PLC, and applications of their learning that they suggest to improve student outcomes for Black Girls in STEM.

This Study's Temporary PLC Design: Context, Methods, and Data Sources

Researchers argue that a PLC values a strong and consistent focus on professional learning to improve student learning (DuFour, 2004). Research also shows that a successful PLC constantly builds participants' capacity to teach well by learning from research and having a reflective dialogue with their colleagues (ACER, 2016; Tran et al., 2013). As part of this study's PLC design, there were three PLC meetings organized by theme, as shown in Table 2. The PLC meetings mapped to the sections outlined in Chapter 2: Review of the Literature and followed the three themes: Big Ideas about the Underrepresentation of Black Girls in STEM, Promising Practices that Empower Black Girls' STEM Identity, and Professional Learning Communities.

Prior to each meeting, participants were asked to read at least one of the four pre-selected articles, as shown in Appendix C. They were then asked to complete a questionnaire that asked which article(s) they read, and they were given the option to type responses to the Self-Study Questions (Appendix B) and the Focus Group Discussion Prompts (Appendix C). Then, they attended one of the two monthly focus group sessions held on Tuesday evening or Wednesday morning via Zoom. The focus groups began with each participant introducing themselves and answering one of the self-study questions. Then, the PI gave a high-level overview of all four assigned articles and facilitated the focus group dialogue using the Focus Group Discussion Prompts shown in Appendix C.

Following the one-hour virtual meeting, participants were invited to stay online for up to 30 minutes to complete an online reflection questionnaire, as shown in Appendix D. The questions asked about wonderings and practices to apply their learning as well as their thoughts on the learning modes. In this study, all participants chose a pseudonym for their name and organization name to minimize the risk of identification and to encourage open and honest

conversation. However, 5 of the 14 participants in the study were Black women; their pseudonyms are marked with an asterisk to acknowledge the potential value their past experiences as Black girls in STEM could bring to the discussion: Square*, AJ*, Mina*, Moxie*, Red*. The other participants included Women of Color, White Women, Black men, a Man of Color and a White Man. I will begin the data analysis with the PLC learning activity most discussed among participants, reading empirical research.

Finding #1: Participants noted that the PLC usefully had them read research, discuss it in focus groups, and reflect on it, allowing them to connect theory to practice.

As a reminder, Research Question 1 was, *In dialogues about research-based supports for Black girls, how do practitioners of informal STEM learning make sense of empirical research as they consider race, gender, and class in their own work?* In their post-meeting reflection questionnaires and individual interviews, participants mentioned that their learning was enriched by participating in the PLC and incorporating the following key learning activities: (1.1) critically **reading** empirical research on Black girls' STEM experiences, (1.2) facilitating focus group **dialogues** to glean real-world insights, and (1.3) encouraging both individual and collaborative **reflection**. Participants said these multifaceted learning activities can empower PLC members to co-create a learning environment for themselves, and support them in pursuing student success – connecting theory to practice.

Finding 1.1: Reading Empirical Research

Foundational to this study's PLC design was participants reading pre-selected empirical research that matched the theme of each focus group. The majority of the participants (Coco, Victor, AJ*, Joy, Matilda, June, Moxie*, Charles, Daniel) mentioned enjoying reading as part of this study and had recommendations for reading within a future PLC (see also Chapter 5). In her

first focus group reflection, Matilda expressed the importance of having the articles in advance and wrote, “I love having time to read and reflect on topics before discussing. This helps me to digest more complex information and have time to process my thinking.” Likewise, even though Victor admitted to not being a “big reader”, he acknowledged the value of reading materials before meetings to ensure everyone arrived prepared for the PLC dialogue. From the readings in this study, Victor learned new terms, and learned distinctions between PLCs and communities of practice.

By reading articles specifically about Black girls in STEM for this study, AJ* said, “I learned a lot about the experiences from a student view (which I think about a lot) but just being able to read about how, especially Black girls have experienced STEM either through their schools or informal learning.” In dialogue about the article she read from the third focus group, AJ* said, “One of the biggest takeaways was [the] informal career progression, which kind of made me feel like I had a lot more agency and power as a professional.”

Many of the participants (Victor, Mina*, Red*, June, Square*, Matilda) also mentioned the benefit of having the articles grouped by theme. For Victor, having a topic for each PLC meeting and reading the research article “framed each conversation to be much more narrow”, meaning instead of broadly addressing topics about Black girls, the dialogue could dive deeper into each topic and have more focused conversations. Square* said, “I have felt very informed because of the reading we had to do.” She liked that the readings were structured by theme “so that we were dealing with a particular facet of the problem or the issue”.

Red* highlighted the value of having access to research papers through the PLC, which, according to her, is typically restricted after leaving an academic institution. In her first focus group reflection, Red* wrote, “I’m glad you provided the actual PDFs of the papers, because

those of us who are not at universities sometimes have difficulty accessing research papers even when they are open access." In her final interview, when Red* was asked about how she participated in this study, she mentioned downloading some of the other pre-selected articles for future reading and said:

> I read them all and I appreciated receiving them. It was like a gift because they're all curated. They're chosen well, they're interesting. They're in my field and you gave me access to them. As a PLC, that was a huge benefit to me, since I'm not in an academic community giving me access to relevant and curated research papers… As a PLC, …having a relationship with universities that would permit the flow of relevant published papers for educational purposes within the community, that's a win! I can tell you that if that was the case, that would influence my decision to pay a membership fee because you would be solving the problem.

Thus, in addition to pre-selecting empirical research for PLC members to read, participants valued the research grouped by theme to allow for more targeted dialogue during the PLC meetings.

Finding 1.2: Dialogue in Focus Groups

Three monthly focus groups functioned as this study's PLC meetings and were held virtually via Zoom. Participants joined either the Tuesday evening or Wednesday morning session. Each session began with participants introducing themselves and answering one of the Self Study questions listed in Appendix B. Then, the PI provided a summary of the four pre-selected research articles relevant to the focus group topic.

Part of a PLC's collaborative culture is grown through reflective dialogue, which includes having conversations about what helps students learn best (Buttram & Farley-Ripple, 2016; Kruse et al., 1994). Compiling their themes, through the focus group dialogue about the articles that they read, many of the participants (Laila, Daniel, Victor, Joy, Matilda, Charles, Square*) said they honestly shared their perspectives and learned from each other's lived

experiences in this study's PLC meetings. In her final interview, Square* talked about the usefulness of the PLC dialogue when she said, "having the luxury of coming back and being able to reflect on that reading with people who understand at a very deep level what the problems are and how complex the solutions will have to be. It's like sunshine. It's like breathing fresh air." Daniel also mentioned that he found the dialogue in the focus groups to be productive. In his final interview, Daniel suggested that his outreach team implemented a community-building activity due to "the community building that we had discussed and talked about in this group".

Since each of the three focus groups were held in a Tuesday evening or Wednesday morning session, Victor, Associate Director at Creative Math Academy, was intentional in attending both sessions to experience the different group dynamics. He reflected on the challenge of trusting others' responses within larger group dynamics, but expressed curiosity about smaller group interactions as well. When asked about his preference for the group size, he described it as "a risk". Victor was unsure of his preference between the dynamics of the smaller group discussions (fewer possibilities for alignment) versus the larger group discussions (less space for each person to share). As a remedy for the group getting too large, in her final interview, Joy recommended incorporating breakout rooms or small group discussions.

Finding 1.3: Room for Reflection

Research argues that two components necessary for educators to change their practice are a community to share experiences, and room for reflection (Tran et al., 2013). In addition to dialogue about the readings in the focus group, participants also had the opportunity to complete an online reflection questionnaire about the reading-based discussion as shown in Appendix D. Among the questions, the participants were specifically asked to reflect on how completing the reflection questionnaire aided their learning process. Several of the participants (Coco, Charles,

June, Square*, AJ*, Matilda, Laila) agreed on the importance of reflection during this study. Charles said, “I think the reflection gives us that conscious pause on the space we shared and the key takeaways.” AJ* noted that the reflections empowered her to “ask questions about how my organization has functioned and where its priorities have been, and [minor things] that [she] wouldn’t have thought about”.

Overall, participants indicated that including reflection, and tailoring its methods to participant needs, can create a powerful space for individual and collective growth among PLC members. Participants had more ideas for their **ideal PLC design** when it comes to reading, dialogue, and reflection, which I will analyze in Chapter 5. Next, I will give examples of how participating in this study’s PLC led informal STEM practitioners to connect theory and practice in their own work.

Connecting Theory to Practice through PLC Participation

Research suggests that informal educators in professional learning can evolve their conversations to ones that analyze the pedagogy and praxis of their programs (Tran et al., 2013). This study’s PLC led a majority of participants (Matilda, AJ*, June, Khalil, Daniel, Laila, Coco, Charles, Mina*, Moxie*) to now actively consider educational theory and its application in their teaching practices. Because of this PLC, participants began taking an analytical approach towards examining their practice, and they were developing new lenses through which to do so. For example, Matilda discussed her organization’s initiative to have a bilingual educator implement an upcoming pilot for a one-week bilingual summer camp, and said, “part of her teaching it, and part of her leading it, and part of her planning it stems from the conversations within our PLC”. According to Matilda, as a Program Director, the PLC “sparked thinking” when designing STEM program activities to “thinking about the *who* of who we are trying to

design something for first and then designing a program", meaning she wants to move towards designing programs that first consider the participants and their needs. Along those lines, June discussed that her biggest takeaway from participating in this study was "thinking about [her] thoughts", then articulating and advocating for her work in science education while validating its relevance to diversity, equity, and inclusion.

By reading research and engaging in dialogue in this study's PLC, AJ* also thought past her day-to-day job functions to apply the research she read as it related to their work. AJ* mentioned that participating in the PLC led her to connect theory to seeing herself as an inclusive educator and change-maker within her organization when she said, "I learned through reading a variety of studies, and having really good discussions, and [got] ideas for how I can improve my organization, how I can become better as an emergent professional. It was a very positive experience."

For Daniel and Laila, participating in this study's PLC allowed them to actively consider educational theory and its application while recruiting staff into their respective organizations. Daniel noted, "PLCs act as a way to re-energize and reflect and re-commit ourselves to the work constantly… I have to continually do that, or it's easy to shift into the perspective of trying to hit the metrics… which aren't always holistically aligned to diversifying the STEM pipeline." Daniel said that participating in the PLC influenced him to be more intentional about hiring candidates for employment who represent the demographic profiles of his organization's student population. In his second focus group reflection Daniel wrote:

> Since our last session, we made three new hires for tutors that support students both academically and personally. We were intentional about hiring tutors [who are] representative of our student population. Since, we have gotten feedback from several families about how much their child looks forward to these individual sessions and that the student was thrilled to work with someone that

> looks like them. This corresponds with some of the takeaways from the recent reading and affirmed the importance for me.

Similarly, based on her experience in the PLC, Laila began to consider theory and its applications to her own work. In her first focus group reflection, Laila wrote, “I plan on adding some new interview questions on supporting underrepresented students in the classroom. I want to know instructors and [Resident Assistant] (RA)’s experiences and how willing they are to modify the classroom experience to ensure underrepresented students have the best learning experience.”

Coco and Charles also mentioned that participating in this study’s PLC had them consider their organization’s programming based on educational theory and its application in their actual teaching practices. Coco said that reading the first set of articles on the stereotypes that Black girls experience was “so powerful in making [her] think about not only Black girls, but all the different subgroups”. Participating in the PLC “opened [her] eyes” to future work and how her organization’s current existing program can address and align to the goals of new student populations and specific subgroups such as girls of color in science. Similarly, in his first focus group reflection, Charles mentioned one way he turned theory into practice when he wrote in his reflection, “This discussion in combination with the articles, inspired me to create a module about owning your authentic self and how to properly articulate boundaries in various settings.”

Both Moxie* and Mina* mentioned communicating empirical research data that they read in this PLC to the audiences of their own organizations. Moxie* used the knowledge gained from the PLC to showcase the research in her organization’s communication and marketing initiatives via social media. In her first focus group reflection, Moxie* wrote, “We’re definitely including more culturally responsive approaches to our delivery of our curriculum.” Since

participating in this study's PLC, Mina* mentioned during her final interview that she also used more data in her work to convey and quantify the importance of representation. Aiming to improve her students' retention in STEM, Mina* has begun incorporating demographic data into her lessons.

In summary, this study suggests that engagement in a PLC can lead informal STEM practitioners to actively consider educational theory and its application in their teaching practices. Next, I narrow the focus of the PLC to findings that participants mentioned as they specifically relate to Black girls in informal STEM learning. I dive into the *big ideas* mentioned by participants, and how the dialogue and reflections on research during the PLC meeting led participants to next steps of *promising practices* and *quick wins* that can be done to advance Black girls' student learning in STEM.

Finding #2: The PLC Design facilitated a cycle of brainstorming Big Ideas, identifying Promising Practices, and piloting Quick Wins that Can Advance Informal STEM Learning for Black Girls

As a reminder, this section also addresses Research Question 1, which was *In dialogues about research-based supports for Black girls, how do practitioners of informal STEM learning make sense of empirical research as they consider race, gender, and class in their own work?* First, I give an overview of the empirical research articles participants read for the first and second focus groups. Then, I address how this study's PLC design facilitated a cycle of brainstorming *big ideas*, identifying *promising practices*, and piloting *quick wins* that could work to improve student outcomes for Black Girls in STEM. *Big ideas* are ambitious goals or questions that aim to identify the root cause behind the underrepresentation of Black girls in STEM fields. *Promising practices* are strategies or next steps that have the potential to address

big ideas, even though they might require more effort or resources to implement. *Quick wins* are actions that can be taken relatively easily and quickly, often individually or with existing resources. These classifications align with critical race and anti-racism theories that emphasize the need to translate big ideas into actions (Delgado & Stefancic, 2017; Pollock, 2008; Pollock & Matschiner, 2024). I now turn to a review of the articles read for the first two focus groups, and *big ideas*, *promising practices*, and *quick wins* as discussed by participants as they relate to Black girls in informal STEM learning.

Overview of empirical research: Informal STEM Education Practitioners and Critical Race Feminism

This study exposed PLC participants to the lens of Critical Race Feminism (CRF) (Wing, 1997) as they examined articles written about Black girls experiencing STEM education. For this study, CRF provided a lens for interrogating the intersectional role of race, gender, and class (Wing, 1997) and how those systems directly influence the attrition of Black girls in STEM; some of the articles used CRF explicitly (Evans-Winters & Esposito, 2010) and others used other narrative frameworks like Standpoint Theory (Scott & White, 2013), which centers the girls' voices as the primary data. For each of the three focus groups, participants read at least one of the four pre-selected research articles to prompt them for the focus group dialogue about the experience of Black girls in STEM education. The subjects of the first two focus group meetings were (a) Big Ideas about the Underrepresentation of Black Girls in STEM and (b) Promising Practices to Empower Black Girls' STEM Identity. Although participants may have read different articles, the common subject area fostered discussions that explored diverse solutions informed by participants' individual interpretations.

To establish some contexts of the first two focus groups, here is a brief overview of the articles that participants read prior to attending the PLC focus group meetings. The first set of articles talked about *big ideas* of how Black girls are viewed in education. They acknowledged the challenges they experience due to race, gender, and class and critiques deficit-focused research that emphasizes stereotypes against them. *Other people's daughters: Critical race feminism and Black girls' education* (hereafter *Other people's daughters*) calls for education research by women and scholars of color on Black girls to shift from deficits to assets (Evans-Winters & Esposito, 2010). *''You would not believe what I have to go through to prove my intellectual value!'': Stereotype management among academically successful Black mathematics and engineering students* (hereafter *Stereotype Management)* describes how high-achieving minority students navigate negative stereotypes to succeed in math and engineering, evolving from proving themselves to finding their own reasons to excel (McGee & Martin, 2011). *COMPUGIRLS' Standpoint: Culturally Responsive Computing and Its Effect on Girls of Color* (hereafter *COMPUGIRLS*) examines the features of a 2-year multimedia after-school and summer program in which the girls had to disprove stereotypes to master the technology, and manipulate technology as a form of self-expression along with culturally responsive practices (Scott & White, 2013). *I don't think it's science:" African American girls and the figured world of school science* (hereafter *I don't think it's science*) criticizes the stereotype of good science students as quiet, polite, and fast-working, unfairly marginalizing African American girls, and discourages their engagement with science (Wade-Jaimes & Schwartz, 2019).

The second set of articles showed more *promising practices* that can improve STEM education experiences for Black Girls highlighting the importance of informal learning, positive role models, and fostering a sense of community. *Missing in Action: Gifted Black Girls in*

Science, Technology, Engineering, and Mathematics (hereafter *Missing in Action*) addresses barriers and recommendations for change related to the underrepresentation of gifted Black girls in STEM due to the intersectionality of race and sex discrimination (Collins et al., 2020). *Black Girls Speak STEM: Counterstories of Informal and Formal Learning Experiences* (hereafter *Informal and Formal*) highlights the I AM STEM after-school program, which fosters positive STEM learning, counters negative stereotypes, and built connections to STEM learning in school (King & Pringle, 2018). *Making "it" matter: developing African-American girls and young women's mathematics and science identities through informal STEM learning* (hereafter *Making "it" matter*) featured Girls STEM Institute (GSI), which effectively improved African American girls' confidence, self-belief in STEM abilities, and overall appreciation for science and math (Morton & Smith-Mutegi, 2022). *Equitable approaches: Opportunities for computational thinking with emphasis on creative production and connections to community* (hereafter *Equitable approaches*) showcased Digital Youth Divas, an out-of-school program for middle school girls that empowers them to build their STEM identity by exploring computer programming and building a supportive learning community (Pinkard et al., 2020).

The PLC design included dialogue and reflection about the research articles to add to participants' professional learning and allow them to make sense of empirical research as they considered race, gender, and class in their own work. As part of this study's PLC design, participants began to transition their *big ideas* to *praxis*, practical application of theory. As a result, one significant theme emerged as participants wondered and discussed with each other, *What practices actually work to empower Black Girls' STEM identity?* Even as the articles addressing *big ideas* and *promising practices* were designed as separate meetings of the PLC, focus group dialogue continued to cycle between *big ideas* and *promising practices.* Big ideas

were thrown out, followed by suggestions for how those ideas could be implemented in real-world practice. Conversely, when promising practices were mentioned, it would spark even more big-picture thinking. Data analysis raised the third category of *quick wins* named in dialogue, meaning an action participants can take relatively easily and quickly, or an action they had already implemented since the last PLC meeting (Pollock, 2008). Drawing on participant insights, this finding offers *big ideas, promising practices,* and *quick wins* to enhance Black girls' student achievement that informal STEM practitioners cycled between during this study's PLC meetings.

Brainstorming Big Ideas

During the first focus group, many participants referenced *COMPUGIRLS*. After reading *COMPUGIRLS* to prompt their thinking in the PLC, some of the participants (Moxie*, Square*, Matilda) mentioned the desire to know what best practices were actually successful in the retention and inclusion for Black girls once implemented. In response to the self-study questions from the first focus group "How many Black girls per year or per program do you or your organization typically serve?", Moxie* responded, "I knew the numbers, I just hate looking at them every time… I considered just during the summer, it's over 2,500 kids, and we have about 10 [Black girls]." She went on to ask rhetorically:

> What do we need to do with our Black girls to make them feel comfortable, create that sense of belonging when they're constantly in this White construct every day 24/7?... How can we collectively have an impact on them of influence on a daily basis? I think those are the things fundamentally that will change, but how do we even get there?

Many of the *big ideas* from participants built on each other during the PLC dialogue as conversations continued. During the first focus group, the PI asked, "What stood out to you as a major cause of underrepresentation of Black girls in STEM?" After reading *Stereotype*

management, Red* began the dialogue by sharing her emotional reaction to reading and *big idea* around underrepresentation when she said:

> My takeaway from the paper that I read was that the unrelenting and systemic trauma of racism, stereotyping and disrespect is a major cause of underrepresentation…. I was just livid. I was just furious. I just had to go for a walk and cool my head off because I was just like, 'These children should not be going through this still.' I was an undergraduate decades ago and went through a lot of the same kind of stuff. Why are we still having this going? It's ridiculous! …barrier after barrier and comment and racism and trauma and stereotyping and them having to navigate all of that. Calculus and differential equations are hard enough without now we got this going on, too, and just the disrespect is just enough to make you just want to smack somebody!

In response, Coco highlighted another *big idea* after reading both the *Other people's daughters* and *I don't think it's science* when she said:

> I'd never given thought to organizations and groups who are fighting racism, and there's groups that are for women, but there's no groups for Black women. There isn't that duality of activities to promote or grow, and so it was really interesting to face the idea that things are not working together even though they're all working towards a greater cause. I think that can definitely be one of those major causes: there is no representation… It was eye opening and made me think about my own experiences as I grew up. A lot of it resonated in me, the fact that, to be a good student, you were the quiet student, you were paying attention, you sat still, you followed the rules. It was very true.

Daniel also read *Other people's daughters* and added another *big idea* to the focus group dialogue when he said:

> I wanted to add on a thought to what Coco had shared in that the need for more research into the Black girl's experience and how that determines policy and decisions that are made. I think that also speaks to another line in that article talking about how making policies and catering decisions to the most marginalized group actually improves the outcomes for all.

Due to the PLC dialogue, Daniel began to make sense of the article he read and added, "I think that resonated with me because… if curriculums are built for the average student (that doesn't actually exist), then we're just maintaining the status quo, but if you build curriculums for the students at the margins, then it improves the outcomes for everyone within that space as well.

Then, Daniel led the dialogue into *promising practices* when he said, "I think the same would go true for building spaces and building policy catered towards the experience of Black girls because they're one of our most marginalized groups."

Although she read *Stereotype management*, Joy added her *big ideas* to Daniel's comments when she said:

> I was just thinking about a comment, Daniel, that you made just about curriculum… It was a really well written article about just how in Critical Race Theory, racism is ordinary. It's like breathing in that structure and thinking about curriculum and especially in mathematics… And Daniel, something you said just made me think about that, of the way that curriculum is being taught or these biases that everyone has because of growing up from a young age in a systemically racist environment where math is taught a certain way, where it's individual and not community and oriented really can be marginalizing for a lot of different communities.

Joy then responded with her own comments on a *big idea* about the PLC revolutionizing STEM learning when she said:

> This article got me thinking about how deep the change is and the revolution of how we teach certain STEM subjects to make it resonate with students. I was reflecting on students and our recruitment efforts, but also deeper than that, of retention. That goes to Daniel, what you're saying of how we teach subjects to really foster that sense of belonging that's authentic and a mathematics revolution or a curriculum revolution in STEM versus some of the things that this talked about in here of just how mathematics has always been taught.

Moxie* responded with a personal reflection and her own thoughts about her own *big idea* of underrepresentation. She said:

> At a very basic level. If you don't feel like you belong, you're not going to be there. You're not going to be engaged… You can talk about all the curriculum you want to talk about till you're blue in the face. I don't trust you, if I don't feel like this is my comfort zone, if I don't feel like you understand my journey, what it takes to sit in that seat and you're going to take the time to make that happen, you can throw whatever you want at me. If you don't understand my struggle and have no desire to understand my struggle, then how can I learn from you and why should I establish some trust levels with you? So, when I read all these things, because I read all the articles, not in their entirety, but I read them all and I felt the

> same way, Red*. I was just pissed off! We keep talking about the same stuff over and over and over and over again and we're not doing anything about it…

Similar to other participants, Moxie* led her comments to *promising practices* about next steps she could take when she said:

> I don't care about your math. I want you to sit down and say, 'Hey [Moxie*], How are you doing today? How was it coming to school today? How is your family? I know I saw your mom, whatever, and I know your brother's doing well. How are you doing?' That's where it starts. Every time I talk about the subject, I'm just so fired up and I'm just so tired of going in circles!

Reflection after the focus group also proved to be an opportunity for more professional learning based on what others discussed during the PLC. After dialogue on the *big ideas* about underrepresentation of Black girls in STEM, the first focus group reflection question asked, "What wonderings do you have? What more do you need to know to make this set of ideas workable in your organization?". In his reflection, Daniel shared his thoughts on *praxis,* moving from *big ideas* to *promising practices.* Daniel referenced Moxie*'s focus group comment above and wrote, "To Moxie*'s point of spinning the wheels, for any group I think there is a right balance of conceptually understanding an issue and then moving towards practical implementation. I don't have an answer to what that balance is right now, but I hope that's an understanding that develops through this experience in efforts to create an effective PLC." This is exactly what happened as participants began to identify *promising practices* and *quick wins* while participating in the PLC.

Dialogue from the PLC about underrepresentation and strategies to improve upon it led some participants to consider how to learn from other minoritized groups. For example, during the first focus group, Matilda suggested learning from *promising practices* of other marginalized groups. She asked, "How do we learn from other minority groups who are going through other similar things, like Arab Americans, the LGBT community, other marginalized groups in STEM

who have had some success (or maybe not) in certain strategies on managing different experiences in the workplace or in education, so that they can support each other?" Fortunately, *promising practices* were the exact topic for the second focus group discussion. Below are more participants' thoughts on their professional learning experiences regarding *promising practices* and *quick wins.*

Identifying Promising Practices and Piloting Quick Wins

The PLC conversations made it clear that after initial prompts from reading the articles, informal STEM practitioners could pinpoint *promising practices* through the PLC dialogue on next steps they could take to improve their work with Black girls. Discussing the readings and their thoughts in this PLC's focus groups led participants to mention *big ideas*, then help each other connect the ideas to *praxis*: (a combination of theory and practice). Sometimes this praxis then evolved into participants identifying *quick wins* that they could easily implement before the next PLC meeting.

Although Mina*, Joy, and June read different articles connected to the big idea of underrepresentation of Black girls in STEM, they all added to the first focus group dialogue on *promising practices* to empower Black girls to change how curriculum is taught, and change policy for social justice. Participants also made sense of the PLC readings to make comparative suggestions about their own programs, and shared their thoughts of *promising practices* with other participants in the PLC dialogue. For example, Mina* compared her organization's curriculum and said, "*COMPUGIRLS* is very similar to the way that we design our programs with Best STEMer, focusing on the social justice or the social impact issues that resonate, it seems like for Black students or Black girls, that those are the type of technical problems that they want to solve." In reference to *Stereotype management* Joy named a *promising practice*

when she said, “this article got me thinking about… the revolution of how we teach certain STEM subjects to make it resonate with students… We need a mathematics revolution instead of teaching students how to play the game, we need to change the game… and make it resonate with students.”

After reading *I don’t think it’s science,* June, an Executive Director at Science To-Go, a science education nonprofit, was also interested in *promising practices* that work for students when she said, “We need to find what really works and what really supports the kids, not just what sounds good on paper when we’re looking at how to teach kids.” June believed there are “plenty of ways to [teach inclusively], affirming students' identities, AND they actually get to learn.” One *promising practice* June identified was to not only teach students based on their experiences (as encouraged in inquiry-based approaches), but also emphasizing direct teaching. June referred to student learning and said, “There can be both. We can draw from your experiences *and* you can learn about things you haven’t experienced, and sometimes you need to just learn your multiplication tables and it’s boring.” June emphasized that studies have shown an improvement in “kids’ self-esteem because they learn and they are capable” compared to other approaches where “they are often lost and confused and frustrated”. Based on her reading, the PLC dialogue, and her own research, June recommended that direct teaching could be a promising practice for underrepresented students.

There was a lot of curiosity about *promising practices* for Black girls that could actually work to enhance their student achievement and empower their STEM identity, showing the need for ongoing research of specific strategies. The data analysis process identified several *quick wins* – practical solutions participants have already implemented or plan to pilot based on their PLC experience. These participant-driven improvements will be highlighted in the findings

below as they were named by participants. Due to this study's PLC design, reading empirical research prompted participants' dialogue and reflections, leading them to pinpoint a range of *promising practices* and *quick wins* that could empower Black girls' STEM identity, showing the power of PLC dialogue to unearth the following solutions from this study's participants: (2.1) including Community Networks of family, Black women, educators, and role models in informal STEM programming, (2.2) Practitioners creating a safe space for Black girls, (2.3) Strategically recruiting and engaging Black girls, (2.4) Creating belongingness and community amongst Black girls, (2.5) Recognizing stereotypes and adjusting to combat them, and (2.6) Leveraging formal-informal education collaborations.

Finding 2.1: Community Networks of Family, Black women, and Role Models

Many participants (Charles, Matilda, Moxie*, Mina*, Red*, June) mentioned the need for the adults around Black girls to form a community as well. In her final interview, Matilda reflected on "all of the articles and the conversations" and emphasized the *promising practice* of "fostering authentic community groups… to support young Black girls in fostering their STEM identity and engaging them in STEM activities". In a different session of the same focus group, Charles added another *promising practice*, and identified that a next step of the PLC could be to support Black women as they support Black girls when he said:

> There're strides being made, but this is a perfect time to have discussions like this to make sure that we're doubling down, and also to figure out ways to not cast Black women on an island, like they're the only ones that can do it from their background... This is a very, very lonely space, and so also educating their peers on how to support each other as they continue to grow in themselves.

Within the PLC focus group dialogue, all five of the Black women participants (Square*, AJ*, Mina*, Moxie*, Red*) specifically mentioned empowering Black girls in STEM by leading their organization's efforts to build community networks; involving family, Black women,

educators, and role models - i.e., themselves. In the first focus group, when recapping her self-study responses to the number of Black girls in her programs, Square* said, “in my organization, I put one [Black girl] every five years, but that’s only because there was one mixed race girl there when I got here. Other than her, I’ve been the only Black girl in the organization.” In response, AJ* was shocked by the lack of data her organization has on the number of Black girls in their programs, and said, “It was impossible to find data for my organization. At one point, I was looking through pictures of the years past… For an organization that's been around for quite some time, it was super hard to find anything about the demographics that we serve at all: Black girl, boy, girl, even Spanish speaking, there was nothing.” Immediately, Laila responded with a *promising practice* that her department had: a year-long, ongoing database project, which she admitted helped her quickly find demographic data. She added, “building that database took about a year, and we were pulling data from three different sources, and aggregating and finding, so it was not easy to just find.” Even still, the PLC dialogue led from *big ideas* on the lack of demographic data to a *promising practice* to have a project to build a database of students.

Reacting to reading empirical research also demonstrated how PLC dialogue could help participants make meaning of their personal experiences linked both to readings and their work with Black girls. *COMPUGIRLS* prompted Moxie* to think about the importance of community. Moxie*, Executive Director at Innobytes, when asked, “What stood out to you as a major cause of underrepresentation based on the article that you read?” she responded by telling the first focus group participants about her background and the *promising practice* of being part of a strong community when she shared:

> I lived in a primarily Black community. I went to a K-8 school where the majority of the teachers were Black and they lived in our community. We walked by houses of people who may not have had kids, but if we had a program up at our school, guess what? They’d be in the audience. My parents belonged to the

> NAACP. We were part of that. I am not super religious, but church was a meeting place…. My brother is an engineer. He was definitely the role model. [From] my parents, we had that support and we had that consistency. Our kids just don't have that. They're looking for us."

Repeatedly, during the PLC focus groups, participants shared their personal experiences prompted by new learnings from reading empirical research. In the second PLC focus group dialogue, after reading *Making "it" matter* on developing African-American girls' math and science identities through informal STEM learning, Mina* empathized with the stressors on Black girls in STEM and added her own *promising practice* that she used to prove the doubters wrong and persevere in STEM. Mina* reflected:

> I was thinking about how it was saying a lot of educators may think of Black girls from a deficiency lens. I'm hearing that discussion, but I think being a part of this demographic, a once Black girl from a low socioeconomic area, and being told by high school counselors and all these other people along the way, 'You don't have what it takes to be an engineer. You don't have what it takes to go to this school.' So, I think about how that can weigh on you heavy, but almost in a way you have to live in an alternate universe where you are empowered and people everywhere believe in you. I feel like I've had to channel a lot of that negative speech to be like, 'Oh, okay, I'll show them. I'll show them.' And it's really taxing mentally when you're always in this state of like, 'Oh, I got to prove these people wrong. I got to prove them wrong. I got to prove them wrong.' On top of not having all of the resources to automatically get into that AP class or that extra tutoring session or that whatever it takes to take you to the next level to get into those good schools or better opportunities. A lot of what I read in this article was just like, yeah, I get it.

Participants also showed that reading articles could continue to raise negative emotions, hinting that a PLC could be used to keep each other encouraged as they consider race, gender, and class in their own work. In a different session of the second focus group, and after reading *Missing in Action*, Red* mentioned a *big idea* to view Black girls from an asset-based lens and then moved to a *promising practice*, when she said:

> I don't want us to get too dragged into all this list of all these issues, issues, issues… I'm like, but the whole funds of knowledge thing is missing here… [Black girls] have a whole bunch of knowledge and skills and stuff to bring to

> this. We're letting ourselves get dragged into a deficit point of view by looking at, yes, okay, it's a chilly STEM climate if you are going to work there, but you can take your power supply, your circuit boards and all your steps to build your project and you can go over to this environment over in the [National Society of Black Engineers] (NSBE) office or wherever else you like to work where you don't feel like the climate is chilly and do your thing there… Don't get distracted by people who say you can't…. We know ways to do that and that's part of our funds of knowledge in our communities… Don't underestimate the power of Black people in our communities who know how to move forward, who know how to solve problems and bring those problem-solving skills to their new engineering career. Lift that up!

Moxie* added more of her thoughts on a *promising practice* to empower Black girls' STEM identity by involving their family and role models. During her final interview, when she was asked "What more do you need to learn to create a PLC to support Black girls in informal STEM education?", Moxie* said, "When I think of Black girls, I don't think about just K-12 or K-16, I think about all of us because our Black girls have Black mothers that need help and don't have a sense of belonging and feel like they're outsiders in the world that we walk in every day. It's heavy." Moxie* added, "I always start all my talks with… 'I'm not special at all. I am just like you guys, but there were some key things that I had and do have: …a background [where] I hear the people that are supporting me, these are the people that aren't going to turn their back on me." This reflection related to Moxie*'s comment during the first focus group about being a role model as a *promising practice* when she said, "All the Black kids that come to my camp, I get them together and I say, 'Do you know why I started this? I started because of you… I'm going to support you.'"

Due to the design of this PLC, many of the participants, including all five Black women participants, highlighted community networks with supportive adults as a *promising practice* to empower Black girls' STEM identity. In the PLC focus group dialogue, they all linked their *big ideas* to the reading on stereotype management and culturally responsive STEM teaching for

Black girls. Then, the dialogue led them to the importance of supportive adults and role models as a *promising practice* to empower Black girls' STEM identity. Next, we will see how participating in this study's PLC led them to another realm of *promising practice*: creating a safe space for Black girls.

Finding 2.2: Create a Safe Space for Black Girls

Some of the participants (Charles, Laila, AJ*, Khalil, Square*) specifically discussed that informal STEM practitioners need to create an environment that is a safe space for Black girls. According to Charles, practitioners need to work on "providing a space exclusively for Black girls, not to isolate them, but to understand their uniqueness and different battles to tackle." During the first focus group dialogue, Laila shared a *promising practice* used by her organization when she said, "in our summer programs for high school students specifically… [ECO University is] intentionally building programs in the evening around that kind of open dialogue, safe spaces for students who want to talk about those situations and issues they're facing." The PLC dialogue led Laila to write her first focus group reflection on how she made sense of the empirical research in her own organization when she wrote, "I would like to see the organization focus on real solutions rather than just band-aids. ECO University tends to focus on increasing enrollments of minorities without offering them much support once they are enrolled...which doesn't do anything to support retention."

During the second focus group, participants read articles that highlighted ways to empower Black girls' STEM identity, and also discussed potential pitfalls to avoid along with *promising practices*. When asked "What stood out to you as one way to empower Black girls' STEM identity?", Square* said, "It's important to make it not about changing the girls' identity or implying that they can have a better [identity] if they're into STEM, but about getting them to

see themselves already in the existing framework so that they already feel a sense of belonging." In response to the same question, but during a separate session of the second focus group, AJ* mentioned a similar *promising practice* when she said:

> Empowering Black girls happens when you give them that space to explore and problem solve and create in ways that are tailored to them, that are creative and open enough so that they can inject themselves into that field without it feeling like I'm an outsider who's prying to fit in. It's more like 'I'm doing this because I'm just someone who can do it.'

Again, the focus group dialogue led participants to make sense of empirical research as they consider race, gender, and class in their own work, and share *promising practices* and *quick wins* from their own experiences. In addition to creating a safe space for Black girls, informal STEM practitioners also mentioned that they can intentionally recruit Black Girls in their programs.

Finding 2.3: Strategically Recruit Black Girls

Based on the PLC focus group dialogue about underrepresentation of Black girls, several of the participants (Red*, Square*, Charles, Victor, Coco, Laila, AJ*) mentioned that a *promising practice* to empower Black girls' STEM identity is to strategically recruit them to participate through their schools or community-based organizations. In dialogue during the first focus group, when asked "What more do you need to learn to create a PLC to support Black girls in STEM?", Charles responded, "What I am realizing, you do have to be intentional. And you have to find, maybe non-traditional ways to get in front of certain target populations." During a separate session of the first focus group when answering the same question, "What more do you need to learn to create a PLC to support Black girls in STEM?", Red* talked about the limitations of her team's "moderate networking" and "word-of-mouth" recruiting strategy. Then, Red* gave a direct *promising practice* that her organization could use when she said:

> If I want that demographic to include, say, specifically Black girls or Black young women, then I need to make an extra effort to go find them and reach them and invite them and encourage and do all that stuff…. That's something that maybe the PLC can do for us collectively as we go forward is help us to know how to build our network in strong ways with sharing our awareness of where we can reach the priority communities that we'd like to reach.

Red* then added a *quick win* – an action that she could take relatively easily and quickly – when she said, "If I knew of three, four, five organizations, schools, Girl Scout troops, whatever the deal is that are predominantly Black girls, I will put those at the top of my list."

Similarly, during the first focus group dialogue on big ideas about the underrepresentation of Black girls in STEM when asked, "What stood out to you as the major cause of underrepresentation for Black girls in STEM?", Square* referred to the *COMPUGIRLS*, and responded with a *big idea* and said, "Like that author, I'm not willing to tolerate the blaming of the girls themselves, for the fact that they're not welcome at the table." She added, "I feel like the complexity of the barriers is so much greater than the simplistic solutions that the people who hold the power are willing to accept." While working through her thoughts as she spoke in the PLC focus group, she still referred back to the article and offered a *promising practice* that she could use when she said:

> In the article, I really liked the fact that it encouraged me to speak up about it, to shout louder, to make it a definite championship thing that I need to do, to champion the cause of the Black girls, but at the same token, for the one Black girl that comes to my program, I don't want to say, 'You've got to represent all Black girls and you've got to do well' and put all of that pressure on them. So, I'm trying to work out how to find that balance.

Square* considered the balance between the practice of championing the cause for Black girls while not pressuring them or blaming them for their lack of representation.

During her final interview, when Square* was asked, "What more do you need to learn to create a PLC to support Black girls in informal STEM education?", Square* had evolved her

professional learning into a *quick win* that she could more easily try when she responded, "learn where the Black girls hang out, what community organizations they rate and trust, and involve those organizations in some way." Square* added a bonus of this application when she said, "generating trust is a heavy lift, but if you can go to where the trust already exists and bridge that" you are more likely to succeed.

Similarly, in her final interview after participating in the same first focus group session dialogue as Square*, AJ* expressed curiosity about *promising practices* in terms of recruiting strategies for Black girls in informal STEM education programs based in southeast San Diego. She mentioned some *quick wins* that might be useful to recruit Black girls: effective language on marketing materials, and to seek out their current club participation or where they are hanging out.

On another note, during Joy's final interview, when asked, "Have you or your organization implemented anything new because of this PLC," Joy reflected on the self-study question that asked, "How many Black girls do you serve in your programs?" In reaction to the prompt, Joy had investigated more into the demographics of her organization's local community, which "has a very high percentage of Black girls, Black women, and immigrant and refugee folks". That discovery led her to wonder, "How many of them are we serving at each program level? She then identified a *promising practice* that her organization could do to get Black girls more represented "at more intense program levels, like our leadership programs, but that requires us to do more work as far as outreach." Because of her participation in this study's PLC, Joy had become more curious about "what kind of representation and leadership would that take in our team and community partnerships with our team that maybe we have, but we need to develop

more to access those groups of folks or provide opportunities in a way that resonates with them in the community."

During the closing comments for the second focus group, Coco highlighted a *big idea* that could be a barrier to the *promising practices* or *quick wins* mentioned above to recruit Black girls into their programs. She mentioned that the students may not know about the participants' organizations when she said:

> I think a lot of it can also be a lack of information. As I am now in this field, I realize there's so many programs out there for engineering, women in engineering, girls to be women, and fellowship programs…. I wonder how many of our students in high schools, in those underrepresented, underserved communities are aware of things like this. And I think more so than anything, how do we get the word out to so many of our students K-12, so that they know that there are these opportunities and finances and knowledge about things aren't going to be a barrier anymore?

Strategically recruiting Black girls to participate in informal STEM learning could be a *promising practice* that can be further discussed and resolved within the PLC. Once Black girls are intentionally recruited and attending STEM programs, the next *promising practice* discussed by informal STEM practitioners is to create belonging and community amongst the Black girls themselves.

Finding 2.4: Build a Sense of Belonging and Community for Black Girls

Over the course of the first two PLC meetings on Big Ideas about Underrepresentation of Black girls in STEM and Promising Practices to Empower Black Girls STEM Identity, participants (Victor, Mina*, Matilda, Daniel, Coco, Khalil, Moxie*) emphasized the importance of creating a sense of belonging for Black girls, which can be done as they build a community for themselves. Similar to the design of this study's PLC, informal STEM practitioners also mentioned creating asset-based opportunities for Black girls. Opportunities intentionally designed for them can foster a sense of connectedness within the STEM community, provide

platforms for them to share their experiences and accomplishments, and become agents for their own STEM learning (King & Pringle, 2018).

In the first focus group, when asked "What stood out to you as a major cause of underrepresentation based on the article that you read?", Victor introduced the *big idea* of building a sense of belonging for his students. He referenced *Stereotype Management* and said, "It made me think and reflect on how much I am putting on the kids to build up their defense mechanisms and how much more focus do I need to be putting on the environments to change and to be more welcoming?"

In response, while referencing *COMPUGIRLS,* Matilda continued the dialogue around the *big idea* of community building when she said:

> What really resonated with me was that it wasn't as much about the STEM that was happening, but about the community building that was happening… part of what should be built in anytime that we are doing teaching or work with children, particularly children of color, is building those communities in a really intentional way and providing them spaces to have each other to build off of and to build their learning off of… I think having those spaces (where they can learn and feel safe to push each other in sort of discourse) is essential for any kind of STEM learning.

After the first focus group, Matilda summarized her earlier *big idea* in her reflection questionnaire when she wrote, "The importance of time and space for community building really resonated with me after these readings. In the *COMPUGIRLS* article the community building aspect of the program was what drove curriculum design and execution with the technology as a way of executing some of this programming (rather than the sole emphasis of curriculum design)."

In response to Matilda, Mina* emphasized the *big idea* of community building, and led into the *promising practice* of girls belonging to a team when she said, "I read the

COMPUGIRLS article as well, and the community building aspect… being able to have them in that peer space where they are sharing ideas, talking to each other, where it's not so much individualistic, you know, 'Did you get the right answer? Yes or no?' It's building something up as team members." Similar to what was experienced in *COMPUGIRLS*, Mina* said that in her programs she has observed the girls becoming their own agents for STEM learning and inviting their friends to join her program and added, "If her friend is in the program, then she wants to join the program, then they want to be on teams, then they want to build this robot together, then they want to come up with this business plan. So, I feel like the community building was informal. Then, I started realizing [that] this is another aspect to why they like these programs… it's really networking in a way."

During the second focus group, the *big idea* of belonging came to the forefront. Moxie* referenced *Missing in Action* and stressed the importance of belonging when she said:

> The fundamental thing with belonging in STEM [is]: First, we have to belong at school. First, we have to belong in our community. Our kids don't feel a sense of belonging… So, you can see how deeply systemic it is within our community, these gender roles, gender stereotypes and way of thinking… I don't want to put our kids in a box.

In response, Coco added more to Moxie's *big idea* as she highlighted the need for students to feel a sense of belonging when she said, "If you don't feel like you belong in the community and you don't belong in the school, you're never going to feel like you belong anywhere… I feel like the root of it all is that sense of belonging, that sense of knowing that you do belong in the place where you are."

Expanding on the theme of belonging, many of the participants (Khalil, Square*, Daniel, AJ*, Charles) proposed the *promising practice* to involve Black girls directly in the design of STEM programs and activities. During the focus group dialogues, participants suggested that

giving Black girls a voice and allowing them to co-construct their own educational experience could make their programs more relevant and meaningful to Black girls' needs and interests. For example, Khalil, a volunteer robotics coach for STEMotics, mentioned during the second focus group that his organization (comprised of all Black children) has the students elect each other to Board positions - "a president, vice president, treasurer… and they each fill in a role so that they are aware of the impact they have on others in the group."

When asked in his final interview what he needed to create and sustain a PLC, Khalil expressed a desire for more time with students and the *promising practice* of a "feedback loop" to ensure the students actually understand the concept he is teaching and not just simply agree. When it comes to designing a PLC for Black girls specifically, Khalil once again emphasized the *promising practice* of feedback and gaining insight into the experiences of Black girls in STEM. He said, "I kind of wish that I could see what it's like living in a black girl's shoes… I'm coming from a Black man's perspective in a white male structure."

In the first focus group, while discussing her appreciation for *COMPUGIRLS,* Square* also mentioned the *promising practice* to include Black girls in the program design and said:

> It was really surfacing the issue, and dealing with it as a valid issue, and making the problems that the girls face part of the work. So, it wasn't about trying to be successful by playing the White man's game. It was about being successful by being authentically who you are, and that's great, and we're going to build on that, and make something beautiful out of it. That was the exciting thing about that article.

The *promising practice* of involving students in his program design was mentioned across Daniel's first focus group reflection, during his second focus group, and during his final interview. Daniel said, "I think it's important to bring Black girls in and say, 'Here's what we're thinking. Is this valuable to you? Is this interesting to you? Is this going to make you feel you belong?', and have them have a seat at the table for designing the program so that [the program

is] meaningful." During his final interview when Daniel was generally asked about his ideal design of a PLC for informal STEM education in San Diego, Daniel recommended "getting the perspective of the students you want to impact… to share their perspective of what is going to be impactful, what is going to be motivating for them, and getting their voice is really crucial to that".

Although she was in a different session of the second focus group, AJ* also brought up a *quick win* that she and other participants could do to empower Black girls' STEM identity. After introducing herself in the PLC, she chose to answer the self-study question that asked, "How do you assist Black girls to manage stereotypes and positively co-construct their identities (STEM, racial, gender, and otherwise)?" AJ* discussed the class that she teaches for Black students, and mentioned, "I try and choose videos that have Black scientists explaining things or giving examples of current Black scientists and kind of co-constructing that STEM identity through them. Doing it is one way that I can assist, manage that stereotype and develop their STEM identities."

During the focus group when asked "How could you concretely empower Black girls in your work?", Khalil responded with a *quick win* used by his organization to "question them about interests, what they would find interesting instead of just repeating the same annual program year in and year out. 'What are some things you'd like to see? What's some things that you saw that you might be interested in or that you want us to dig deeper into?' I think that might be helpful in recruiting and then retaining more Black girls in STEM." In response, AJ* offered another way to accomplish the *quick win* of asking the students about their interests when she said, "as I was reading, I was thinking to myself, 'How did [the program educators] find out that fashion and music was what middle school girls are really into right now? Is that what middle

school girls are always into?' It's just having to ask the kids what that is. Something I could concretely do right now is as the kids are coming in asking them, 'What's in right now guys, what are you into?' So, I can better tailor projects and different programs to them."

In summary, according to the participants, building a sense of belonging and community for Black girls may help to improve their student outcomes in STEM, and lead them to become agents for their own STEM learning. The *promising practice* to give space for Black girls to be their own best advocate evolved into *quick wins* during the course of the PLC dialogue. One *quick win* identified was to involve Black girls directly in the design of a STEM program and ask them directly about topics they enjoy, and include it in the teaching materials. Next, participants also mentioned a *promising practice* for themselves that may empower Black Girls' STEM identity: to recognize stereotypes and address them.

Finding 2.5: Recognize and Address Stereotypes

Participants highlighted that reading about the experiences of racial and gendered injustice led them to a more humanized understanding of the legacy of structural barriers for Black girls in their own work – a crucial *big idea*. By participating in this study's PLC and reading the articles, some participants (Khalil, June, AJ*, Laila) learned more about the specific challenges that Black girls have to face while participating in STEM learning. Researchers have said that valuing the perspective and experiences of Black women can reduce the tendency for leaders to overlook, downplay or underestimate their success (Farinde & Lewis, 2012; Zamudio et al., 2011). This *promising practice* continued to be a theme brought forward by participants within this PLC.

For example, after reading *I don't think it's science* and engaging in focus group dialogue, this PLC raised more questions for June as she considered race, gender, and class in

her own work. June talked about understanding the *big ideas* of diversity issues in general. Reflecting on the core question of the PLC, June was also curious about *promising practices* and *quick wins* to address the needs of specific student populations like Black girls without neglecting others (ex: Latina girls, Black girls and boys, or all girls). Other than recruitment or bringing in role models, June wondered "are there ways to be more specific in support [of Black girls]?" Additionally, June mentioned that since her participation in this PLC, she now wants to learn and hear more *big ideas* and specific examples of stereotypes that Black women experience. She desired to maintain a proper balance of learning by hearing examples while attempting to not retraumatize Black women who may share their experiences within the PLC.

For other participants, reading the empirical research prompted them to make sense of *promising practices* in their own work. For example, in his final interview, Khalil, a volunteer robotics coach for STEMotics, reflected on *I don't think it's science*, and mentioned that reading that article has helped him more readily recognize and address the archetypes for a good science student (quiet, polite, works quickly, etc.). The data and research showed him that most students are not sticking with STEM, so Khalil now takes his role and the *big idea* of attrition more seriously. By participating in the PLC dialogues, Khalil connected his learning to a *promising practice* when he said, "It definitely put more pressure on me as a coach to be more mindful of how I interact with the students and also… the widespread issue of getting students involved into STEM".

Even more than the *promising practice* to be mindful of stereotypes, participants added that a *quick win* for practitioners to try could be to understand and address the struggles of race and underrepresentation that their students face. After reading *I don't think it's science* about stereotyping, and the focus group dialogue about *promising practices* related to addressing

stereotypes, in his final interview, Khalil shared about a *quick win* that he has tried since participating in this study's PLC. He talked about his experience with a Black girl in his program who has a type A personality. Khalil mentioned that he intentionally tried "to make sure that [the educators] got other students to speak up instead of pushing her to be more quiet and stereotypically ladylike", which directly opposed the good science student stereotype in *I don't think it's science*. Moreover, in his second focus group reflection, Khalil wrote, "I've been more attentive to the Black girls in our robotics program and ensure they feel included and that their voices are heard. We encourage Black girls to speak confidently and eliminate micro-aggressions noted within the groups."

Conversations in the PLC about recognizing and addressing stereotypes had some participants grappling with more *promising practices* and *quick wins* they could learn from each other as PLC members. Following Khalil's comments about the importance of providing positive recognition to Black girls in his classroom during the first focus group, Laila wondered about similar concerns for her own students and considered the *promising practice* of leadership development when she asked, "How do we best train program personnel to understand how racial stereotypes or racism in general can manifest, and what are we doing to help students manage that or at least become better aware of… any microaggressions that we might have that we didn't realize was a microaggression?"

As mentioned by participants, professional learning through reading empirical research and dialogue in this PLC led them to realize that recognizing and addressing stereotypes could be a *promising practice* that leads to *quick wins* that may empower Black girls' STEM identities.

Finding 2.6: Formal - Informal Collaboration

In dialogue after reading the articles on *promising practices* to empower Black girls' STEM identity, participants noted that empowering Black girls' STEM identity does not stop with the girls themselves. Many of the informal education practitioners (AJ*, Matilda, Laila, Charles, Victor, Mina*) mentioned that collaboration with formal educators can be crucial in empowering Black girls' STEM identity. Combining their perspectives, a *big idea* could be for informal education practitioners to collaborate more often with traditional schools and in-school educators. That way, informal education practitioners can provide opportunities for Black girls to access advanced STEM courses and competencies early on, helping them break through potential barriers and build confidence. The PLC dialogue led participants to identify *promising practices* and *quick wins* that they could implement in collaboration with formal education.

Specifically, after reading *Equitable approaches*, in the second focus group, AJ* identified the *big idea* of the typical heavy lift of formal teachers, and offered that the load can be shared in informal education when she said:

> I think when it comes to empowering Black girls, it's a community approach and I think sometimes everything is pushed onto formal learning teachers. 'You have to do everything all at once and you have to make sure that they get all of the facts and you're doing social-emotional learning and you're building this STEM identity and you are combating stereotypes as you are managing a classroom of 34 students.' I feel like informal learning really needs to be a space… of community partnerships or kind of taking that load…. There has to be balance.

Matilda, Director of Education at the Learning Lab, has a formal school background and grappled with the *big idea* that informal education can be a space for interdisciplinary work that is not typically in formal school settings. Through the PLC dialogue, Matilda began to ask about *promising practices* when she said:

> STEM in a silo isn't really something that engages young children, but in the formal school setting, as kids grow, they're put into these individual classes that

> teach specific subjects that are not actually interdisciplinary… and I think that does tend to alienate and isolate kiddos as they grow… How do we then as informal educators help to create those spaces, spaces to have interdisciplinary work happening?

When asked for closing comments in the PLC focus group, Matilda continued to ask, "How do we better connect informal education spaces and organizations with formal schools to help find those kids? Who are we missing? How do we help them? How do we help them build not only academic capital, but social capital, social networks through our organization?" Matilda, continued her thoughts and shared her ideas on *promising practices* when she said, "I really do think it has to be a partnership with schools. I think otherwise informal networks just end up in these sorts of spaces where we don't get everybody that's missing." Matilda understood the benefits of both formal and informal education along with the need for a partnership between them.

Not only did participants working in informal education agree that partnerships are essential, informal education participants working within formal education institutions also agreed on the *promising practice* of collaborations. For example, Laila, Associate Director of pre-college programs at ECO University reflected on collaborations and said, "working with community partners, that's probably my favorite part of my job because it does cut through so much red tape and allows us to do a lot of DEI-type initiatives that the University wants to see, but has so much red tape that prevents us from actually achieving the goals they want us to." In the second focus group, Laila expressed her frustration with the restrictions that she encounters when she said:

> I cannot have a program for just girls. I used to, and I almost got sued and I was forced to change all the language on the website and the University legal team got involved because someone else wanted to sue. …It is just such an odd thing where they tell us they want to see more young girls in STEM, but I can't have a program for young girls in STEM. So, partnering with a different organization

> that is doing [programming for girls] allows me to at least feel like I'm doing something to achieve that.

A few participants reflected on their own experiences and issues in the formal school system as they were pursuing STEM and agreed on the benefits that informal education can provide. During the second focus group, Charles referenced a *big idea* in *Missing in Action* that talked about the shortcomings of formal education when he said, "One of the data points that you provided in the first article that resonated with me just from my past experiences was the underrepresentation of Black girls in Algebra in middle school, but then the overarching majority of that representation in high school in junior and senior year." Charles suggested a *promising practice* to partner with formal educators to get the necessary classes and competencies taught to students early. Charles added a reflection on his lived experience as a Black student when he said, "I remember realizing how different honors classes were in high school and even in middle school, but nobody actually directly telling me how important it was to actually pursue those… I remember going into high school and I tested into Algebra my first year, even though I took that in middle school… I remember sitting in this class the first day… and I got up and walked out and said, 'Put me in Algebra 2'… Us supporting students to empower them to do that same thing and recognize their own ability is going to be huge to place them on a STEM trajectory."

Following Charles' comments in the second focus group, Victor also reflected on *Missing in Action* and added his own thoughts about a *promising practice* to supplement formal education with informal education when he said:

> Algebra in eighth grade stood out to me and it's something that I want to try to be intentional about. Since we are providing students math classes,… I want to make sure that we actually put them on some sort of track to do Algebra with us. Even if their school's not going to let them do Algebra, they'll do Algebra with us by eighth grade.

By reading articles and engaging in dialogue, informal STEM practitioners representing both formal and informal learning settings gained a stronger appreciation for the *big ideas* and *promising practice* of collaboration between these environments.

In conclusion, when prompted by reading research specifically about *big ideas* about the underrepresentation of Black girls in STEM and *promising practices* to empower their STEM identity, informal STEM practitioners made sense of empirical research as they considered race, gender, and class in their own work. The PLC dialogue allowed participants to talk through their own *big ideas* and help each other identify *promising practices* and *quick wins* that would impact their *praxis*. Participants proposed, in sum, that informal STEM educators and educational leaders can: form supportive community networks amongst themselves, create an environment that is a safe space for Black girls, strategically recruit Black girls into their programs, build a sense of belonging for Black girls and include them in the program design, practitioners can recognize and address stereotypes, and collaborate with formal education. Next, I discuss the benefits that participants said they experienced during this study's PLC, followed by the definition of a PLC in their own words.

Finding #3: Benefits of a PLC Experienced in this Study

As you have seen in the previous findings, **reading** research, having **dialogue**, and room for **reflection** (Finding #1) were aspects of PLC design that participants valued, and helped when they were cycling between *big ideas*, *promising practices*, and *quick wins* (Finding #2). Additionally, participants identified four noteworthy benefits of this study's PLC design for informal STEM practitioners. As we will explore in more depth in the following sections of this finding, some of the benefits that participants named were: (3.1) making underrepresentation in STEM seem like a more manageable problem, (3.2) going from working in silos to forming

connections, and (3.3) learning from one another. The next part of the analysis discusses how participants say they benefited from this temporary PLC, and how they defined a PLC. Then, Chapter 5 will then look at a conceptual framework for an informal STEM PLC based on what participants said would be ideal.

Finding 3.1: Underrepresentation in STEM is a BIG Problem that can be more manageable in a PLC

Initially, some participants felt overwhelmed by the vast challenges in STEM education. However, their experience in this study's PLC transformed their perspective into a more manageable one: participants noted that talking about big ideas, then promising practices, helped them realize that they needed to collaborate with each other in a PLC. In their individual interviews, some of the participants (Square*, Victor, Matilda, Khalil) specifically mentioned that underrepresentation in STEM is a large problem. Participants like Matilda mentioned that she has very few opportunities to solve larger systemic problems, but found space within the PLC to consider these topics. Matilda said, "In the course of my day, I feel like I am doing more, like tactical, logistical problem solving as opposed to systemic problem solving". By systemic she means "not just community, but also… my own organization that I have the power in my role to… support or think about or challenge or change."

Similarly, Victor lamented feeling like the participants in the PLC get "the most negative, pessimistic version of me sometimes" when he thinks about the problems children face, but noted that having a shared experience with the PLC participants allowed him to refocus and "impact the things that I can impact". Victor added, "I think I'm constantly going through a cycle of 'There's a million things that are affecting the children that I work with, and it's hopeless and I can't fix it all' and then coming back to 'okay, well, what can I fix?'" while leaning on others to

handle areas he cannot. Thus, while underrepresentation of Black girls in STEM is a big problem to solve, participants acknowledged that a PLC can give informal STEM education practitioners an opportunity to solve greater systemic and social problems related to underrepresentation in STEM in a more manageable way. Next, I will discuss another benefit of the PLC experienced by participants who usually feel as though they are working alone in silos.

Finding 3.2: From Silos to Connections

Research claims that PLCs in education have grown in popularity as the view of education has changed from an isolated classroom to an interrelated body with aligned nationalized standards (Townley, 2020). This sentiment was also shared by the informal educators and educational leaders in this study's PLC. According to the participants, this study's temporary PLC effectively broke down silos within the informal STEM education field, and fostered a strong sense of connection and collaboration among practitioners. Several participants (Victor, Mina*, Joy, June, Moxie*, Square*, Charles) highlighted the value of networking with like-minded individuals who shared their passion for education, even if their specific roles differed.

Beyond initial networking, participants identified possibilities for ongoing connection. Moxie* described her overall experience in this study as "very enlightening and beneficial". She enjoyed the engagement in the meetings with like-minded people sharing their experiences and opinions because "a lot of times we feel like we work in these silos". Likewise, June's biggest benefit of participating in this study's PLC was connection. June said, "I work kind of soloish, so I like to check in with people sometimes… I think there's a benefit to knowing people in your community, knowing what people are doing."

Joy also enjoyed meeting people with a different business culture, and this PLC was "a reminder of how important those relationships are and networking in that way, but also learning together in that way." She highlighted the benefits of connecting with like-minded individuals who have similar missions, but do different types of tangentially related work. For example, the study contained members who may not work in the nonprofit sector like Joy, but "they may work in a company organization, as a teacher, or within the larger education system". Victor mentioned his experience in this study's PLC, where he exchanged contact information with other participants doing similar work. He also discussed feeling a sense of camaraderie with others doing similar work, and named two benefits of a PLC as "having a space to talk about stuff that we think about but maybe don't talk about as much", and "learning that you're not alone in the way that you feel doing this type of work".

When asked, "Have you implemented anything new because of this PLC?" Square*, an Executive Director, detailed that the PLC served as a catalyst in her decision to leave her old job and her subsequent success in landing a new job "in a place where inclusion and belonging is at the center, not a peripheral nice to have." She admitted, "I've left and I feel good about that, but I probably wouldn't have felt so good about it if I didn't know that you guys were all out there…. I'm really glad to have done this [PLC] at this juncture." Further emphasizing the importance of the PLC, Square* said, "That's what the learning community means to me… I've got my own tribe that likes me and will support and nourish me." In her first reflection, Square* wrote, "Coincidentally, we have been going through a strategic planning process the last few weeks. I feel like being in this program is giving me courage, language, and knowledge to feed into that process." Overall, this study's PLC served as a powerful antidote to isolation, fostering a sense of connection among previously siloed informal educational practitioners.

Through this study's PLC, Moxie* was reminded to re-engage with other participants, and they made plans to have sidebar discussions. Further, Moxie*'s organization is a fiscal sponsor for another participant's organization, and she engages with another participant in a collaborative consulting business relationship. Moxie* believed that by working together, she can make a greater impact on her own clients, who she said are "the students". She is currently planning for "seven or eight programs that require a lot of resources (manpower and time)". She asked, with so many students to serve "what's the hesitation behind us getting together?" Based on these perspectives, because of this study's PLC, the participants have already identified benefits of a PLC that include making the big problem of underrepresentation more manageable to solve and going from working in a silo to connecting with others. Next, I discuss what participants said they *learned* about PLCs by participating in this study's PLC via engaging research about needed and possible ways to support Black girls in STEM.

Finding 3.3 Professional Learning from One Another

According to scholars, being able to share STEM learning, advice, and mentorship with colleagues in a learning community can be extremely valuable for an educator (Kezar et al., 2017). From the assigned readings, Square* learned more about "how deep the problem is" and described it as "an academic problem to solve a social problem". She is aware that whatever solutions are created, there will always be more layers and more gates to break through. Also, by participating in this study's PLC, Square* learned that "informal education takes so many different forms", and "how widespread the similar challenges are across a variety of fields and levels". Square* learned that sharing challenges and perspectives allowed participants to "map some of the things that you wouldn't normally come up with yourself".

In her final interview, when Matilda was asked how the PLC could help change her program design priorities from what is being taught to the audience, she said, “I think being able to hear from others in sort of the way that they either already support kiddos and learners or things that they have already tried would beneficial. So that we’re not trying to reinvent the wheel if there's already something that is a design framework or something that's already worked well for others that we could apply to our own programmatic design, that would be something to be super helpful and learning from others experiences and navigating this as well is, I think, always helpful and could be a really big support.”

This study allowed some participants (Coco, Mina*, Red*, Laila, AJ*) to share successes, challenges, and collaboratively rethink their approaches to informal STEM education. Specifically, Coco said, “It was nice to find a whole new group of people that have similar challenges, similar struggles, but also similar successes, and how we're all kind of moving the needle forward little by little, but it’s happening.” Mina* said, “I got to meet new people and hear their best practices and even some of their pain points when it comes to informal learning in STEM.” This study helped Red* think about how to outreach with the community in new ways, and “get a successful outcome (X), or change what the successful outcome is (X’)” while sharing the successes and failures along the way. Laila also appreciated getting insights from educators in different organizations facing similar struggles in education while networking with them to rethink approaches to education. Overall, this study’s PLC fostered a collaborative environment for educators to share *big ideas, promising practices,* and *quick wins* to learn from each other’s mistakes, and find new solutions.

In summary, this study’s findings clarify the concept of a PLC and its associated benefits to informal STEM practitioners. According to participants, this study’s PLC design, organized

around reading, discussing, and reflecting on research, can be a valuable tool to help them address the complex *big ideas, promising practices,* and *quick wins* around underrepresentation of Black girls in STEM education. Participants reported that this study's temporary PLC fostered connection with like-minded colleagues, effectively breaking down silos within informal education, and learning from one another. Furthermore, having explored the numerous benefits of this study's PLC as described by participants, this chapter now delves into their own definition of a PLC, presented in the final finding below.

Finding #4: PLC Participation Led to Informal STEM Practitioners Defining a PLC

During this study's temporary PLC, the initial interviews revealed a lack of familiarity with the term "Professional Learning Community" among participants, or even any prior experience with one. However, through experiencing this temporary PLC, participants' perspectives shifted dramatically. In their initial interviews, participants were asked, "Have you ever participated in a Professional Learning Community (i.e., the San Diego STEM Ecosystem)? How long did you participate? Describe your experience." During the final individual interviews, each participant was asked to articulate their own definition of a PLC, offering valuable insight into their evolving understanding.

During Mina*'s initial interview, she said that she's been on a few calls with the San Diego STEM Ecosystem, but has not been formally engaged with the group. When asked, "Who should be invited to participate in the PLC, Mina*'s lack of experience with a PLC led her to say, "I wish I had more of a reference for how a typical PLC is so I could provide more context." However, in her final interview, Mina* confidently defined this study's PLC as "a community of people who are rooted in helping students get into STEM, digest STEM, and are a group of people you can lean on for support and can help each other on your professional pursuits." Coco

had participated in the San Diego STEM Ecosystem for about eight years in different capacities. She also participated in a one-year "virtual PLC focused around Spanish Education programming and resources", but did not remember much more about it. During her final interview, Coco defined a PLC as "a community of people that are learning together, growing together, but also have a common goal." When asked to describe her experience in this temporary PLC, Coco finished her description and said, "Overall, I felt [the PLC] was really engaging and informative, and I'm sad that it's over. I was waiting on my next round of articles." Both participants had prior experiences in non-impactful group settings, but were now able to see a PLC as an opportunity to learn and grow together.

As part of their initial interview, some of the participants requested the definition of a PLC due to lack of familiarity with the term. For example, Joy requested the definition of a PLC and was read the definition from Chapter 1 of the dissertation proposal. In response, Joy mentioned her connection with an organization's quarterly meeting and said, "As a younger educator, it helped me meet diverse people in the field and learn more about [other] careers and program models." In her final interview, Joy realized ways that a PLC can support her current endeavors and defined a PLC as "a group of individuals who collaborate, who work together on learning together to improve their practice". Similarly, when Red* was asked if she had participated in a PLC, she was unsure and wanted to ensure we had matching definitions. After giving her the definition of a PLC from the dissertation proposal, Red* responded that she was involved for two years in a weekly PLC as a part of someone's dissertation research group. When asked to describe her experience, Red* said, "It was a great experience... We all learned from what she was studying, and that has helped to shape the ways that we teach our students since then." In her final interview, Red* defined a PLC as "a community for the members who

are professionals to further develop their professional skills as they learn and share together". While both Joy and Red* have had prior experiences with organized learning communities, there initially was not a direct connection with their experience and the term PLC. Yet, their understanding and connection to a PLC evolved by the final interview.

Unlike many of the participants, Victor had some familiarity with participation in a formal PLC during his final five years as an in-school, public, high school teacher. He described that the PLC was mostly used for "vertical planning" purposes to align pedagogy across middle school and high school at the district level. However, Victor's final interview showed an evolved view of PLCs, where he defined it as "a group of people getting together to try to improve their craft and educate themselves… for student outcomes".

Based on (1) this study's PLC design, (2) participants' *big ideas, promising practices,* and *quick wins* to improve student outcomes for Black Girls in STEM, and (3) the benefits that participants experienced, participants defined a **Professional Learning Community (PLC) as *a collaborative group of educators and professionals working together, sharing knowledge and experience on deep issues in their work, and supporting each other on shared goals to improve their practice and ultimately improve student or organizational outcomes.*** In the next chapter, we turn to how participants leveraged their insights from participating in a temporary PLC to design their ideal PLC, including their description for the framework of a PLC to advance informal STEM learning for Black girls.

CHAPTER 5: DATA ANALYSIS - PART 2. IDEAL PLC DESIGN TO ADVANCE INFORMAL STEM LEARNING FOR BLACK GIRLS

Transitioning from the previous chapter's analysis on using research to spark *big ideas*, then refining them through PLC discussions into *promising practices* and *quick wins*, this chapter dives into the core of Research Question 2, which was: *In what ways do practitioners of informal STEM learning propose the design of a Professional Learning Community to help them more positively affect the educational experiences of Black girls?* Leveraging professional learning from the third focus group on *Professional Learning Communities*, we explore participants' visions for an ideal PLC design for themselves to support informal STEM learning for Black girls. In response to the interview question, "What is your ideal design of a Professional Learning Community for informal STEM education in San Diego County?", in the coming findings, I describe participants' suggestions for their ideal PLC. Later in this chapter, I address participants' recommendations for the pedagogical design of their ideal PLC for informal STEM practitioners in San Diego County.

Informal STEM Learning PLC Conceptual Framework: Signature features of an Ideal Professional Learning Community for Informal STEM Educators and Educational Leaders in San Diego County

A conceptual framework for a PLC was suggested by participants as they dove further into answering Research Question 2, which was *In what ways do practitioners of informal STEM learning propose the design of a Professional Learning Community to help them more positively affect the educational experiences of Black girls?* Research argues that PLCs can be effective when there is strong leadership support, shared goals, and self-directed reflection (Fulton & Britton, 2011; Townley, 2020; Leithwood et al., 2008; Young-Wallace et al., 2020). These

themes inspired a question in the pre- and post-interviews that asked, “What is your ideal design of a Professional Learning Community for informal STEM education in San Diego County?”, along with a series of follow-on questions, as shown in Appendix A and Appendix E. Based on their responses, I compiled their ideas into a conceptual framework for an informal STEM PLC as shown in Figure 3. This chapter addresses four key questions: *What* knowledge and skills would enhance learning in a PLC? (Finding #5), *How* should PLC members engage with the learning materials and each other? (Finding #6), *Who* should be involved in the PLC? (Finding #7), *Why* is a PLC suitable for informal STEM practitioners? (Finding #8).

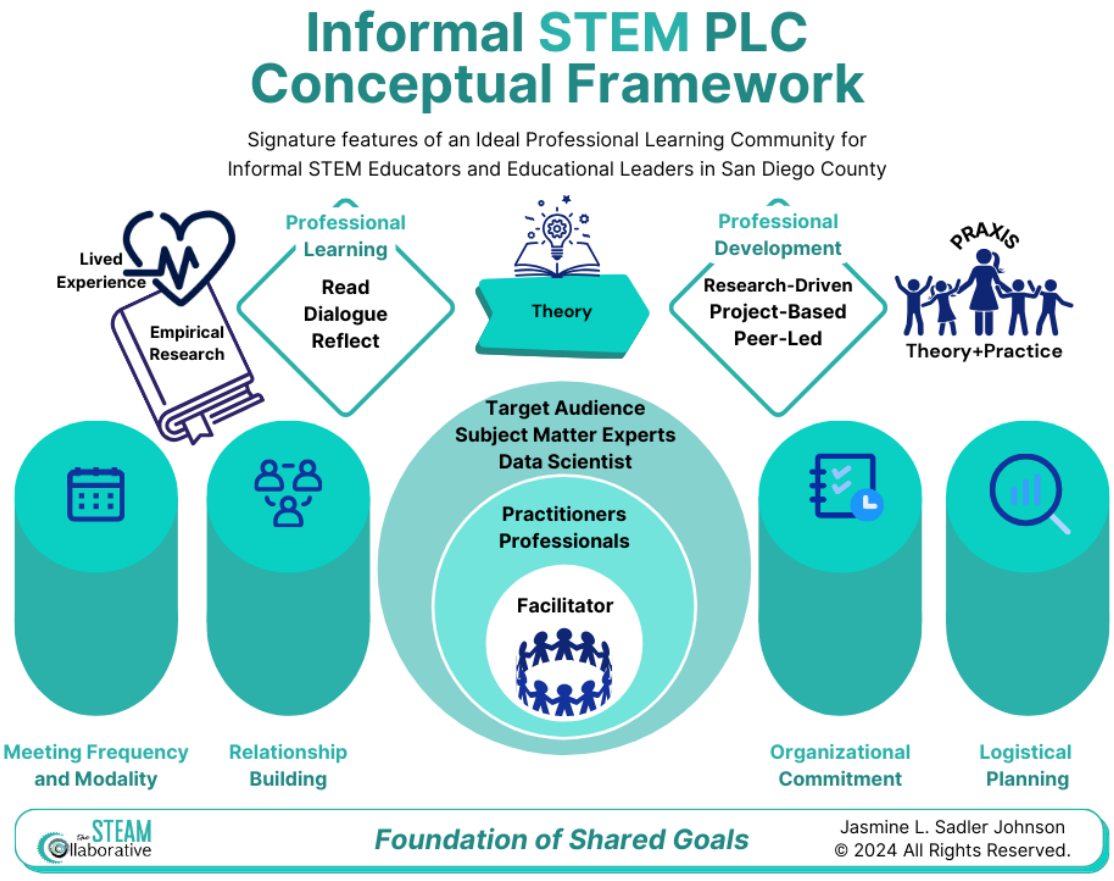

Figure 3: Informal STEM Learning PLC Conceptual Framework

In this chapter, I discuss the ideal PLC Framework based on findings from this study. In the coming findings, participants gave suggestions of *What?*, *How?*, *Who?*, and *Why?* in relation to the design of their ideal PLC. I first start with ways in which the PLC design could be enhanced beyond the research-driven learning activities of **reading** empirical research, **dialogue** amongst each other, and **reflection** through **collaboration.** Their ideal PLC can also include **effective professional development (PD)** learning approaches. It would also include additional **human resources** beyond STEM practitioners, and meet **operating conditions** that can make this framework suitable for use for an informal STEM PLC. I now turn to the pedagogical design for their ideal PLC with their take on research-driven professional learning in a PLC, since that was core to this study's PLC design. First, I give an overview of the empirical research articles that participants read for the third focus group, and participants' high-level thoughts on collaborating within their ideal PLC. Then, I share the *What?* - participants' responses for how the PLC could help them with professional learning, including PLC design enhancements for the goals and activities they desire in a PLC.

Overview of PLC Empirical Research

The set of articles for the third focus group talked about Professional Learning Communities as a complementary solution to increase representation of Black girls in STEM. *Making Science Matter: Collaborations Between Informal Science Education Organizations and Schools* (hereafter *Collaborations with Schools*) showed that formal-informal collaborations in science education can boost student learning, teacher skills, and create equitable learning communities (Bevan et al., 2010). *STEM teachers in professional learning communities: From good teachers to great teaching* (hereafter *STEM teachers in PLC*) highlights the characteristics of a strong PLC and suggests that STEM teachers working together in strong PLCs with shared

goals and continuous improvement practices can lead to increased teacher satisfaction, retention, and ultimately, higher student achievement in STEM fields (Fulton & Britton, 2011). *Building an Informal STEM Learning Professional Competency Framework* (hereafter *Professional Competency*) highlighted the need for research-based professional learning in informal STEM that focuses on the learning that individuals gain and apply (Heimlich et al., 2021). *Leveraging Communities of Practice as Professional Learning Communities in Science, Technology, Engineering, Math (STEM) Education* (hereafter *COP as STEM PLC*) suggested that a STEM CoP can transform into a powerful PLC by intentionally focusing on student learning and fostering collaborative knowledge creation (Townley, 2020). In summary, the articles from the third focus group explored the benefits of collaboration for student learning, professional learning, and creating equitable learning environments. Next, I discuss the ideal informal STEM PLC Framework based on findings from this study - beginning with their recommendations for how to enhance the PLC design.

Finding #5: What knowledge and skills would enhance learning in a PLC?

As a reminder, this chapter addresses Research Question 2, which was *In what ways do practitioners of informal STEM learning propose the design of a Professional Learning Community to help them more positively affect the educational experiences of Black girls?* For this study's PLC design, reading empirical research, facilitating focus group discussions, and time for individual reflection were the cornerstones of professional learning. Interestingly, although participants were not explicitly prompted about *what* they wanted to learn in their ideal PLC, some participants discussed ways that the current study's design elements could be **enhanced** in their ideal PLC to answer the question *What knowledge and skills would enhance*

learning in a PLC? Then, this finding analyzes data exploring how participants envisioned collaborating with each other in their ideal informal STEM PLC.

Finding 5.1: Reading Enhancements

When discussing opportunities to enhance the reading aspect of the PLC design, Laila envisioned that the PLC could have a shared depository of resources (research data, PD, meeting minutes, PLC member contributions) accessible to all organizations within the PLC. In addition to learning from other programs at competing institutions (which is how she typically learns), Laila emphasized the importance of reading other people's research. She suggested that the PLC could implement a journal club where members select articles to read and discuss articles' findings and their impact.

When specifically asked, "What more do you need to learn to create a PLC to support Black girls in STEM?", Red* expressed her interest in reading research about Black communities when the researchers are Black. She said that she would prefer "curated catalogs/ libraries of the research results from Black researchers and Hispanic researchers and Indigenous researchers and deaf researchers about, and of, and for their own communities, instead of people from outside their communities presuming to jump in the mix and decide that they really know best how to run research."

Similarly, in her final interview, June questioned the quality of published research on informal learning and asked, "How good is the research on informal learning?" June acknowledged that people introduced to research by current authors could be "turned off by the lack of talk of inclusivity", and suggested that a PLC could consider how to increase the number of DEI research authors. June said, "I would be interested in what the *minority* of education researchers are doing for classroom practices and teaching practices" and she "would like to see

more people in the narrow space at the intersection of the schools and education, specifically elementary curriculum research." June also expressed an interest in joining a PLC that prioritizes advocacy for teaching practices and protocol for making changes at the school system level including learning the politics behind it.

Matilda, the Director of Education at the Learning Lab, also expressed interest in curated articles since she serves children in pre-school and TK through second grade. When asked, "What more do you need to make a PLC workable for you?", Matilda would have liked more articles or more dialogue on supporting younger children and their caregivers in informal STEM education. She wondered:

> How to better transfer research-based ideas, or ideas not grounded in my particular exact setting? How to better transfer those, or redefine or rethink them in a way that could be more applicable for me? Taking that theory and how to better make it into action for me with the population that I serve.

During her final interview, Matilda and the PI brainstormed and agreed on the idea of the PLC continuing to have theme-based readings, but the different articles in each theme could represent a different age group. Matilda remarked, "That would be super helpful… that, I think I would love because I think it would help ground some of my initial thinking."

In their focus group reflections, a few participants (Charles, AJ*, Khalil, Victor, Daniel) privately shared their difficulties with reading research articles and made alternative suggestions to reading within the PLC. Also, the terms used in the articles themselves were a bit challenging for participants. Khalil wrote, "Reading the information took some time since I was not readily familiar with the jargon, but once I could fully comprehend the article it was extremely beneficial." Victor wrote, "The discourse is helpful as reading all the articles is difficult and also other people in the group seem to be more knowledgeable about the vocabulary that is used in the research." However, Daniel mentioned that he made it a point to familiarize himself with

unfamiliar words and phrases. He also mentioned his experience in other PLCs, and suggested that the future PLC could use a book with more digestible language as the PLC's common research to read.

Relatedly, in his focus group reflection, Charles wrote, "Prioritizing time for reading is always a challenge. Offering audio or video articles can also serve as a way to receive essential content for informed discourse." In his final interview, when Charles repeated his concerns about the length of the reading, the PI discussed her strategy for reading long articles as she prepared an annotated bibliography for her doctoral work. Charles then mentioned that methods to read empirical research might be a good topic for the PLC to learn "how to digest and approach large bodies of work", as a way to "strengthen our minds or our resolve to digest that as if we were PhDs". Participants mentioned that reading research could be enhanced by having articles in curated catalogs and having research in formats other than articles to read.

Finding 5.2: Focus Group Enhancements

To enhance the dialogue with other PLC members, Laila thought that smaller online focus groups with guided topics could also be beneficial for the PLC. She listed examples of topics: "How to speak in a more inclusive way, How to handle conflicts between students of different backgrounds, How staff should handle certain situations, How to modify curriculum to be more inclusive." Similarly, Mina* suggested that each PLC meeting should be focused on specific themes with invitations sent to people who are "directly impacted" by that topic. For example, if the topic is on "Board membership and Board retention or development, [she feels] like people who have very strong Board members or best practices for Board members should be in that conversation, and people who are aspiring Board members should be in that conversation."

Moxie*, Executive Director at Innobytes, thought that some of the focus group discussions were the same discussions that are held in the traditional education system, which is a useful critique about the design of the dialogue within this study's PLC focus groups. Moxie* highlighted the need for members to "step outside of their comfort zones or just the constructs that they actually are working in", and her desire to join a PLC with people who are willing to push boundaries and embrace a "growth mindset of expansion". She emphasized the importance of defining the PLC's goals and purpose, and approaching solutions to education with an "engineering mindset" when she said, "I feel like we're still just thinking simply… there's so much opportunity out there." For example, Moxie* highlighted that private schools and Sidwell (Quaker School) are thinking differently than the traditional education system and remarked, "Not like they're any smarter… or risk averse, but somebody's got to take the chance." She added, "Somebody's creating it, then why can't it be me? Why can't it be collectively us as a team?" In summary, according to participants, including topics, inviting people who are directly impacted by a topic, and thinking with an innovative mindset could enhance the focus group design.

Finding 5.3: Reflection Enhancements

Aligned with the design of this study's PLC, Laila felt that reflections are most helpful when they are done right after the discussion session, and she recommended reserving time during the PLC to reflect. However, some variation emerged regarding the most effective reading-reflection methods. Daniel found it more valuable to reflect with someone else in a paired discussion a couple of days or a week after the PLC meetings rather than writing a reflection immediately. Moreover, when discussing the usefulness of the focus group reflections in her final interview, Laila suggested that the PLC have a plan in mind of what to do with the

reflection data when she asked, “What are going to do with that information? How does it get aggregated? What will it be used for? How can we make the questions? How do we design the surveys so that they’re not just being done to get done and that it’s actually going towards something?” Thus, it may be best to ask PLC members about their desired preference for reflection, and understand if the reflections will be used to further enhance participants’ learning and/or if their reflections will be used for data collection.

Finding 5.4: Collaboration

Moving beyond the connection that they experienced in this study’s PLC (mentioned in Finding #3), participants could already see future opportunities for **collaboration** and consultation. During her final interview, included in her definition of a PLC, Laila acknowledged that the PLC members’ common issues cannot be resolved individually, and said, “We’re stronger as a group”. Similarly, in her final definition of a PLC, Square* said, “if you sum your efforts and your learnings and your design around what change do we need and how are we going to make it? If we can do that in a **collaborative** way on different axes at the same time, then I think there’s more scope for genuine, meaningful, and lasting change.”

Participants could also see opportunities for their own growth and development by learning from each other in a long-term PLC. Because of this study’s PLC design, AJ* said, “I think I have the opportunity to grow as a **collaborator** in informal learning, which I haven’t done as much as I now feel empowered to do.” Joy also saw a benefit in expanding her network of people that she “can call on for questions and getting unstuck”, or have members of the PLC participate in Professional Development opportunities. Charles defined a PLC as a space for learning “what you feel you need to grow whatever you’re trying to focus on” within a specific focus area whether it is business, finance, STEAM, etc. Charles likened a PLC to an “in-person

Reddit… where you have a forum that meets in different capacities, where somebody can drop a conscious thought in a chat group, or meet regularly to discuss certain topics, or whatever is kind of going through your mind around that primary focus of whatever that PLC is doing."

Reflecting on the PLC itself, many participants mentioned that **collaborating** within a future PLC could give them access to more Black girls to recruit them into their programs. For example, Laila, Associate Director of pre-college programs at ECO University, thought that a PLC could help her institution gain access to students by reaching out to organizations that serve underserved communities rather than relying on word-of-mouth recruiting efforts for individual students and their families. Laila also highlighted her institution's legal limitations in starting a PLC that exclusively serves Black girls, but was excited at the idea of partnering with organizations that may have initiatives that serve Black girls. In her introduction for the third focus group, Laila recalled a successful past **collaboration** and said:

> I think that partnering and **collaborating** with organizations allowed my organization to be a little more innovative and come up with new ideas that we probably wouldn't have on our own, especially during Covid. Sometimes when you are part of a very large organization, your structure is too rigid for you to be as creative as you want to be. So, partnering and collaborating allows us to do that and kind of circumvent the rigidness of a larger institution. So those are the benefits and why we really collaborate at my organization."

So, an ideal PLC for informal STEM practitioners would foster opportunities for collaboration as a means to enhance their professional goals.

In summary, participants gave recommendations of *What knowledge and skills would enhance learning in a PLC?* Participants mentioned that in their ideal PLC, reading empirical research could be enhanced if it were presented as a depository of resources about a community by representatives of that community, including lesser-known researchers, and organized by student ages. Also, if the PLC offered a learning opportunity on digesting empirical research, the

reading part of the PLC could be enhanced. When it comes to the focus group design, participants mentioned that it could be enhanced if the focus groups were organized by topics related to their professional practice, while encouraging PLC members to have a growth mindset and inviting people who are directly impacted by a topic. While reflections were recognized as valuable to the PLC design, there were no overwhelming preferences on how to do it. Thus, PLC members could choose the most impactful way to reflect, whether it is done during meetings, independently after meetings, or collaboratively with other members. I have just discussed Professional Learning in terms of *What* would enhance participants' learning; I now turn to Professional Development (PD) which is *How* they learn (Heimlich, 2021).

Finding #6: How should the PLC learn? Effective Professional Development (PD) Learning Approaches

While traditional Professional Development (PD) focuses on changing teacher practice and improving student outcomes (Darling-Hammond et al., 2017) without necessarily grappling with issues of race, other PD models explore critical issues like race and equity in education, *then* ideally ask participants to name concrete applications for their practice (Pollock, 2008). However, good PD always involves collaboration in analyzing one's practice with others. Hence, there has been a rise in models that emphasize PD within a PLC that can expand notions of teaching and development (Darling-Hammond et al., 2017; Townley, 2020). Unfortunately, many of the participants in this study, especially founders of their own organizations or volunteers, have not experienced PD within informal education (Heimlich, 2021). So, this was their first experience with learning in a structured way as it concerns their needs as professionals and their students' needs within the context of informal STEM education. Even still, participants who work within an informal STEM organization may participate in limited or inconsistent PD,

but, in this study, desired for it to be more **effective PD**. Informed by both research and their own experiences, participants in this PLC emphasized the importance of prioritizing PD, which was defined as *structured learning experiences designed to enhance professionals' knowledge and skills, leading to positive changes in their practices* (Darling-Hammond et al., 2017; Heimlich, 2021; Pollock & Matschiner, 2024). When asked, "What more do you need to learn to create a Professional Learning Community to support Black girls in STEM?", their responses suggested a preference for effective PD, that incorporates a full range of *research-driven*, *project-based***,** and *peer-led* learning approaches.

Aligned with the literature on **effective PD**, participants in this study's PLC broadened the concept of collaboration to include working alongside each other during fully collaborative PD activities (Darling-Hammond et al., 2017). When asked how the PLC could help her organization, Laila said, "...helping us outreach to underserved communities that would be a bit of a barrier to reach on our own coming from a larger ECO University." She added, "A PLC could help with… professional development opportunities coming together to co-train staff on certain situations that happen with students from different backgrounds." Coco discussed how this study's PLC already **effectively** helped her to network, learn new strategies, and gather resources to implement in a "PD structure that we have with our educators".

Similarly, AJ* mentioned that this PLC used **effective PD** to enhance her learning. AJ* suggested learning through "professional development and [an accessible] community of people with the same goals that can help turn [her] ideas into reality". When asked how the PLC could help her or her organization, AJ* said the PLC could "support and motivate [her] as an educator to continue the growth and success of [her] organization", and "continue [her] learning" while helping her become a "more holistic professional". Khalil, a volunteer robotics coach, also

suggested **effective PD**, which could incorporate ongoing workshops and resources on teaching *pedagogy* that would be beneficial for himself and other coaches in his organization.

Several participants mentioned that they prefer **effective PD** learning approaches that would engage them in a new way. Below, based on feedback from participants, I will discuss the learning approaches that they mentioned for **effective PD** in their ideal PLC, including: (6.1) *research-driven,* (6.2) *project-based,* and (6.3) *peer-led* learning approaches to collaboration and resource sharing.

Finding 6.1: Research-driven PD

This PLC was designed to have participants read research and discuss it. Yet, a majority of the participants (Square*, Joy, AJ*, June, Red*, Laila, Coco, Moxie*, Khalil, Daniel, Charles) mentioned the importance of data collection in research as it relates to learning within their ideal PLC. Some even suggested that the PLC could conduct research to fill gaps in literature - a noteworthy ambition. Square* highlighted the benefits of "pooling resources and information" from the "much wider data pool" of the PLC, which can be "analyze[d] much more effectively". She expressed her desire for more "useful research" on "ground-level, community-based organizations" that may not "have the scope or capacity or the resources to do useful research and to put things into practice as a result of that research". Perhaps her ideal PLC could include doing research within it.

In her ideal PLC, June preferred *research-driven* PD that may interrogate conflicting bodies of research. For example, in regards to educational practices informed by cognitive science, June thought that the PLC could research and compare explicit teaching pedagogical techniques against Next Generation Science Standard case studies about pedagogy. June emphasized that an inquiry approach to teaching is actually an equity issue, stating that inquiry

methods benefit the less vulnerable students "who already have a lot of background knowledge, who already have a lot of experiences, already have a lot of exposure", while it disadvantages the most vulnerable students. June then expressed concerns about the damaging effects of inquiry approaches on students' learning. She explained that these approaches have been proven ineffective in teaching students to read and argues against their promotion in math and science as well. Given her thoughts about some of the problems of "inquiry learning", June mentioned that she would be interested in joining a PLC with researchers who conduct rigorous studies on teaching practices.

In addition to the PLC members *consuming research* for learning or practice, a few of the participants (Red*, Coco, Moxie*) mostly centered on the idea of a PLC *conducting research* with the populations they serve, with some interesting comments related to Equity and Impact Reports- a very different PLC design element than reading research. This aligns with research that suggests that collaborative teams engage in active research that builds a culture of experimentation within a PLC (Eaker et al., 2009). Using a *research-driven* learning approach, Red* made a suggestion that her ideal PLC could get funding to conduct its own research and she said, "Consider writing a proposal to NSF (or one of these other multi-trillion dollar funding sources)" to conduct research that collects narratives from "Black women who have become STEM professionals to think about: When they were Black girls…. 'What was the turning point? When was the turning point? What was happening in your life when that turning point locked in for you?'" She likened this research to "cultural anthropology, but we actually have living people right here, you, me, and some other folks who traveled that whole path, and we're still here, and were black girls."

Moxie* also talked about the PLC engaging in *research-based* PD where PLC members conduct research about the students and communities that their programs serve. When she was asked, "What more do you need to create a PLC to support Black girls in informal STEM Education?", Moxie* concluded her response with the statement, "If we can't make the commitment, how do we expect to initiate change? We have to be more deliberate and more intentional." As an example, Moxie* talked about previous research she had done on an elementary school near her organization's new location. The school is predominately Hispanic, African American, and Asian with 86% of students below the average math level, and 70% below the literacy level. Moxie* showed concern for the future of these students who are unsure if they will graduate from high school, or what will come of their lives once they graduate high school with such low scores in math and literacy. Moxie* emphasized how a PLC could utilize research to understand the people and the communities that participants work with and said, "...if we collectively as a PLC, evaluate it down to that LCAP (Local Control and Accountability Plan) level of all of these different schools and what we can do, that's starting to change."

On a similar note, Coco mentioned that her organization had created Equity Reports in the past to learn more information about a new area, and recommends that as a way that her ideal PLC could engage in *research-driven* PD. The reports included: populations, the different number of students in each grade level, the number of adults and their different job categories, education pathways and highest levels of education. During her reflection from the first focus group, Coco indicated that such equity reporting could be part of a PLC when she said, "I am going to work with my team to have more data about our service population and how to obtain this in a way that is not intrusive or adds more steps to our participants." Combining these thoughts, participants suggested that research should drive both their professional learning, and

professional development within the PLC. Participants specifically called out the desire to interrogate the quality of current research, curate catalogs on less popular research topics, and conducting research through the PLC. Next, I will discuss a *project-based* approach to PD suggested by some participants.

Finding 6.2: Project-Based PD

Some of the participants recommended that their ideal PLC could develop its members professionally through *project-based* PD, meaning working towards a result (Khalil, Moxie*, Daniel, Mina*, Square*), which may include completing a project (Moxie*, Mina*, Victor, June, Coco). Victor mentioned that his ideal PLC would do *project-based* PD since it could allow for the PLC members to celebrate small outcomes to fuel motivation and participation. Mina* said that she preferred "*project-based* and results-based" learning approaches then said, "I like to put things into action. So, if one month we're talking about grants, and the next month we're talking about board members... I would love for someone to say, 'I listened to our conversation about the board members, and I ended up finding a board member. Let me tell you what that process was like.'" Mina* said this type of learning "would be a really good thing to see, because that also shows measurably that the PLC is impacting people." Similarly, June thought that if she were leading the PLC, she might consider leveraging the PD style, "but then [the teachers] would go back [to their teaching environment] and try them and then report back."

Moxie* also preferred *project-based* and results-oriented PD in a way that is considerate of her time. Moxie* suggested that the PLC be "deliberate about what we're doing". Moxie* wanted an ideal PLC to be focused on outcomes and collective impact rather than just networking. For example, she considered that the PLC could collectively host a STEM field day with different schools for *project-based* PD. She added that companies who say they want a

diverse workforce should be invited to show kids the reality of being an engineer, including the non-glorious side of "sitting at a computer crunching out some numbers all day".

Although not directly calling out project-based learning, Coco suggested that the PLC could result in a presentation or *collaborative piece* that brings it all together. She preferred a classroom setting for the PLC with "front-loaded" information (read an article, watch a video, do an action) followed by collaborative, brainstorming, and reflective discussions with the group. In the temporary PLC, Coco appreciated having a structure built around an *end goal* of the PI's work to create this framework when she said, "My end goal is supporting [the PI's] work... It doesn't have to be something physical that I create necessarily, but the experience has to have some purpose." In her ideal PLC, that goal could be learning, researching, or developing a product such as a report or article. Coco said, "If it's something that I'm going to be putting my time and energy and effort into in a PLC, I want to have something that I walk away from the experience with that I can then either apply or use or at least change my mindset in some way."

In summary, reading curated, quality research led participants to envision themselves conducting research projects within the PLC. In the following section, I discuss *peer-led* PD, the third type of PD learning approach mentioned by participants.

Finding 6.2: Peer-led PD

Again, participants desired **effective PD** that enhanced their professional knowledge and skills, leading to positive changes in their practices. In fact, many of the participants (Joy, Mina*, Matilda, Khalil, Charles, Laila) desired *peer-led* PD sessions to cross train PLC members in specific topics, learn from other PLC members, and share success stories from learning within the PLC. In her final interview when asked about her preferred learning approach, Laila said,

"either *peer-led* or instructor-led for some topics, especially in areas that I know I'm not an expert in, like curriculum development and content curation."

Joy, a Program Manager at Wave, expressed a preference for *peer-led* PD through "research applied to real-life experiences" and said, "I always appreciate when people share their real-life experiences". For her ideal PLC, Joy considered including *peer-led* topics based on PLC members' expertise including sharing relevant articles and discussing their significance to the presenter's organization (Heimlich, 2021). She said that peer-led learning "allows people to share their own expertise, which is cool versus an instructor." Joy enjoyed how learning in this study was set up in a way that combined "academic research and practice in your programs at the same time" because people may not have that opportunity in their jobs. Research suggests that while life experience equips adults for daily life, understanding skill and knowledge gaps and engaging in targeted learning can contribute to PLC members' professional growth (Heimlich, 2021).

Joy also mentioned her need to "build capacity for more programs" and mentioned that she could leverage the PLC to train new employees, as well as provide PD for existing staff members. She said, "...something that we keep hearing is wanting to learn more about different roles in education organizations or wanting to connect with different people." For example, Joy considered including opportunities for staff members to learn about grant writing and grants management. She added, "I feel like there's a lot of jobs that people don't even know exist unless you meet someone who has it." Joy suggested informational interviews as a way for PLC members who are early in their nonprofit career to "learn about other organizations that maybe have similar missions but different types of programs". Along those lines, Joy mentioned that informational interviews could benefit people in leadership positions who may be "more

removed from actual facilitation or program development or design" providing "more robust interaction" through feedback and input to the programs they are managing. Joy also talked about the importance of learning about different roles in education organizations and building connections with other professionals in the field. For example, a program coordinator could work closely with someone who manages the entire program budget at the director level.

However, not all participants preferred all three learning approaches discussed in this section. For example, Matilda expressed her interest in "peer-led or professional development instructor-led training" rather than a project-based approach due to the additional time requirements, and having to justify the time commitment to her boss. She said, "I would be able to more immediately participate and get something out of a group that wasn't based [around a project]." While some participants did mention instructor-led training, which is typical in PD, many more participants mentioned their preference to learn from peers, especially those within the PLC. Ultimately, among the research-driven, project-based, and peer-led learning approaches, the PLC members can select the right one to best accomplish their goals. I now discuss participants' ideal PLC members and participants – the *who* of an ideal PLC.

Finding #7: Who should participate? Human Resources

The most important element of a PLC design might just be the PLC members themselves. Victor ultimately wondered, "Who's all gone be there?" and re-emphasized the importance of having the right people in the PLC, people who he believes can make a significant impact on supporting students. As we will explore in more depth in the following sections of this finding, participants emphasized that central to the PLC's success is a diverse network of participants. Compiling participants' interview responses to "Who should be invited to participate in a PLC?", the ideal PLC members could consist of: (7.1) a well-respected and trusted Facilitator, (7.2) a

core group of like-minded PLC members, and (7.3) an extended group comprised of Subject Matter Experts (SMEs), notably, caregivers of Black Girls.

When envisioning ideal members for an informal STEM education PLC, Victor said that the PLC member selection should be "intentional and organic" with "some sort of filtering system in the fact that you got to select who participated and then also they had to, in a way, be part of your sphere of influence to participate." Joy listed PLC members in STEM education who are necessary to create change when she said, "You would want diverse people in [the PLC] who represent different race, ethnic, religious backgrounds, genders, and experiences in the field, like people who work in K-12 education, higher ed, [community colleges], nonprofits… even foundations that provide a lot of funding for different types of education that work in between nonprofits and the district." Khalil mentioned that the diversity of experience and perspectives of PLC members can help to ensure the PLC can discuss both theory and practice, ultimately leading to a more impactful PLC.

Finding 7.1: Well-trusted Facilitator

A respected leader (hereafter *Facilitator*), this study's Principal Investigator (PI), provided guidance and vision for the PLC's professional learning. Square* mentioned that an added bonus to participating in this PLC was the second-hand learning that happened "for [her] to learn through [the *Facilitator*] and not have to go and do a PhD." Some of the participants (Daniel, Moxie*, Charles, Square*) also credited the PI on the group of participants in this study. During his final interview, Daniel positively described the collection of participants as "very committed to the ideas, to their mission, and what their organizations are doing". When he was asked, "What more do you need to learn to create a PLC to support Black girls informal STEM

education?", Daniel said that the PLC "would need someone with the lived experience, who has the vision, and work experience to facilitate and lead" such a group effectively.

Some participants inquired more about the PI's path that led to this research study. Coco expressed a desire to lead a similar research study as this one, except she suggested replacing the target audience of the articles with Latinas in informal STEM Education. In response, the PI encouraged Coco to explore her interests through a doctoral program. The PI also shared examples of qualitative research projects conducted by her classmates as a means to motivate Coco to get credit for the research and reading that she is already doing in her spare time. After AJ*'s interview, the PI shared her own journey of pursuing higher education and launching a successful business built on networking. AJ* had even more questions about logistically putting on STEM education programs. The PI walked AJ* through a Standard Operating Procedure for a previous year's informal STEM summer camp, which included reserving field trips, ordering lunch, and subcontracting community partners. The PI was able to draw from her past experience as a Quality Engineer to ensure informal STEM programs are repeatable and sustainable. Therefore, in a future PLC, participants desired a PLC *Facilitator* who possesses a strong grasp of the PLC Framework, and the ability to leverage their own experience to understand and address PLC members' diverse interests.

Some of the participants (Moxie*, Coco, Red*, Matilda, Square*, Victor) mentioned the importance of having a *Facilitator* to organize and coordinate the PLC meetings. Square* expressed concern about the sustainability of the PLC when she said, "Who's going to find the articles and do all of the legwork that [the PI] did to make it worthwhile, because it has to be curated, and that's a job in itself." On a similar note, Coco expressed interest in researching topics ahead of time so that the PLC is engaging to others, similar to how the PI pre-selected

articles for this study's PLC. Also, Matilda appreciated having a *Facilitator* leading the focus groups providing "different questions to prompt our thinking". Moxie* stressed the importance of communication for the PLC to maintain momentum when she said, "There has to be somebody that's able to communicate the progress no matter what so that we stay with that cadence of moving forward". Participants recognized the efforts of the PI, and suggested that the PLC have a *Facilitator* to do similar functions.

A few of the participants mentioned explicitly that they only joined this research because of their prior relationship with the PI. For example, in her final interview, Red* highlighted that she was initially unsure about what a PLC is or what this one would become, but was willing to participate due to her trust in the PI. Victor appreciated the PI's facilitation skills which ensured everyone had a chance to speak up during the focus groups without any dominant voices overpowering the conversation. During his final interview, Victor lamented feeling like the participants in the focus group get "the most negative, pessimistic version of me sometimes". However, the PI validated Victor for showing his genuine emotions to the participants, and shared how all of the participants can relate to the hopeless feelings he shared. This shows that having an encouraging, and well-trusted *Facilitator* can also contribute to the success of a PLC.

The PI proved to be the most essential human resource for this study's temporary PLC, suggesting that an ideal PLC should also include a similar *Facilitator* leadership role. In addition to learning from each other, participants used one-on-one time with the PI during or after their interview to add to their professional learning. Participants also suggested that this leader could also be responsible for more administrative tasks such as confirming the meeting logistics including the date, times, location (virtual and in person), and collecting the articles to read

ahead of time. Next, I discuss participants' idea of a core group of PLC Members who represent informal STEM learning and industry professionals.

Finding 7.2: Core Group of STEM Practitioners and Professionals

During their final interviews, several participants mentioned the concept of having a core group of dedicated members. Square* highlighted the need for a diverse "quorum" of participants in the PLC, with a "range of professions and subject areas". She liked the diversity of participants in this study including STEM professionals, educators, and non-profit community leaders with different perspectives. Khalil added, "those heavily involved with students" including teachers, professors, educators, researchers, mentors, and volunteers should be included in the PLC. When Mina* was asked about her ideal PLC members, she listed the following: "people who are in the classroom with students, people who are decision makers like the Director of Education, [Executive Director] (ED), operations people... anyone in the non-profit that works with kids directly or impacts kids directly should be the typical invitee". Coco emphasized the importance of "engagement across the county and representation across different aspects of informal education" including program designers (program leads, site leads) and practitioners (site teachers, site educators).

Charles further discussed including individuals "from these different walks of life" who have access to the population we are trying to serve, including STEM educators, administrators, principals, nonprofit leaders, real-world industry professionals who are up-to-date on new and emerging "cutting edge" technologies, academics/ researchers for data-driven topics who have a PhD, Doctorate degree, or are a student. Red* discussed the importance of having a diverse range of professionals, including in-classroom and out-of-school educators. However, when it comes to inviting traditional teachers to participate in the PLC, Victor, a former formal educator,

acknowledged that it might be difficult for teachers to attend the meetings due to their busy schedules. Victor also thought that the PLC would have to add value to teachers without them feeling attacked by suggestions for improvement.

Based on the reading *Professional Competency* from the third focus group, Daniel thought that the PLC members should include individuals from different stages in career development (including evaluators and standard setters) alongside contributors from all levels of education. Similarly, Joy mentioned the need for diverse representation in the group, including people at different levels of leadership positions and from various organizations and educational spaces because she thinks "everyone can be a leader in their position and everyone's voice counts." Joy also thought that the diversity in participants' career stage could present opportunities for learning and growth through "generational dialogue". Square* shared the importance of having "people at different stages in the career path to make it rich". She added, "you get to a certain point in your career and you forget what it's like to be in the other stages, or [on the other hand] you haven't had [leadership] experience, so you can't think more strategically." Normally, Square* is accustomed to peer-to-peer discussions at the manager or director level, and said, "I'm really enjoying hearing more youth voices and hearing more early-stage perspectives."

Interestingly, including PLC members with geographic diversity was important to some participants. In this study's PLC, participants across San Diego County were included to understand if geographic location is a deterrent for PLC participation. Joy mentioned that she considered geographic diversity to capture different perspectives within a region to make sure "that the whole county is represented". She mentioned that even just five miles apart, San Diego can be geographically different. Also, Matilda, brought up the desire to have a PLC that included

participants from her geographic location of North County, San Diego. When she talked about geographic location, Matilda said, “I just think that would help to localize things somewhat and think about what are the resources that are *here* and how to learn from people that are already potentially doing some work or that are struggling with their learning about the same things.”

When asked, in general, for her ideal design of a PLC for informal STEM education in San Diego County, Square* mentioned that San Diego is a “really unique city… bordered by all these different physical regional boundaries like the mountains and the desert and the sea and the border”. Square* added her frustration with San Diego being a border city to Mexico and a “refugee hub” resulting in “anti-Black racism” from multiple cultures. She highlighted her leadership role in an organization for East African Women and the “intersecting prejudices” because being “Black and African *in* America is different [than] being African-American.” Square* said, “I would like [San Diego] to be *really* multicultural, with multiculturalism as its defining problem to solve”.

Combining their thoughts, participants recommended that the human resources making up their ideal core group of informal STEM PLC members are classroom educators, program designers, non-profit leaders, or educational leaders at various career stages, which are the same job roles as participants in this study. In addition to the job roles who participated in this study, participants also mentioned including real-world STEM industry professionals, research practitioners, and formal classroom teachers. Geographic representation and geographic diversity should also be considered in the core group of PLC members. Next, I discuss other human resources who were mentioned by participants that could make up an extended group of PLC members.

Finding 7.3: Extended group of Subject Matter Experts

Compiling participants' interview responses, participants said that beyond the core group of informal STEM Educators and Educational Leaders, their ideal PLC could also include an extended group of Subject Matter Experts (SMEs). Laila said, "I can even imagine smaller teams outside of the Leadership Team being created depending on the initiative that they're pushing at the time, or maybe it's like ad hoc committees that get created based on the need." Participants recommended that this extended group of PLC members participate quarterly or as needed for consulting. As we will explore in more depth in this section, representatives from the PLC target audience, industry professionals from adjacent fields, and a Data Scientist can bring valuable knowledge and perspectives to the extended group of PLC members.

Representatives from the PLC Target Audience: Caregivers and Black Women

Participants suggested inviting PLC members who represent the target audience most relevant to the PLC's focus area. For this study which was centered around Black girls, when participants were asked about ways in which the PLC could better help them support Black girls, many participants' (Charles, Matilda, Mina*, Victor, Coco) recommended inviting caregivers and Black women to participate in the PLC. When asked specifically about a PLC to support Black girls, Charles said, "It's less about what we need to know. It's really who we need to know". His thoughts included inviting Black women "to understand the nuances of what a Black girl goes through in both college and career". Charles posed the question, "'Black girl, what are you going through?' Even before you could talk about what's hindering you from getting into STEAM careers, it's like, what are YOU going through?"

According to participants, the caregivers of Black girls can offer invaluable insights into the unique cultural experiences and motivations of the target population. Several participants

specifically suggested inviting caregivers to their ideal PLC, an unusual recommendation that differs from the typical literature on PLCs. Further supporting this point, Matilda and Mina* both mentioned that the transportation responsibilities for informal STEM learning primarily fall on the parents. Thus, Matilda highlighted informal education for her young student population as a "unique opportunity in our environment where we do have adult caregivers there as well."

Matilda referenced *Missing in Action* during her second focus group when asked, 'What stood out to you as one way to empower Black girls' STEM identity?', she stated, "I think that is so critical to not only invest in kids, but also their families (particularly with the articles' focus on trying to recruit kids younger). So much of that is centered around their family and their groups of influence at home." She added, "I think investing in caregivers at an early age too, and their own STEM identity is so important to helping to foster [the STEM identity] with kiddos as they grow through education."

On a similar note, in her final interview, when asked "What more do you need to learn to create a PLC to support Black girls in informal STEM education?", Mina* said, "I would need the parents' perspective to feel confident in creating [a PLC]." She asserted, "I do think it's a value-add to have a couple of parents involved who are really interested in STEM". Once the PLC is deciding on a workable solution, Mina* said, "I feel like the parent could vet if that's going to work, because they have to drive them, take them, be a part of [the solution]." She added, "They're the decision makers ultimately for their children so I wouldn't want to build something that isn't convenient for them." Inviting the caregivers of the target population to participate in the PLC can help ensure the PLC is both culturally responsive and aligned with the needs and interests of Black girls.

While not all Black women are parents or caregivers, some participants suggested that other Black women can still participate in this PLC to help give the PLC insight on their lived experience. When asked specifically about a PLC to support Black girls, Victor discussed the need for Black women to be represented among those involved in the PLC aimed at supporting Black girls in STEM education. Similarly, in her own interview, Coco said that she would "want it to be authentic" so she would want to "learn more about the experiences of Black girls in STEM… and even speak to Black women who have gone through the struggle and really get their insight". She added, "Being female, but also being of Hispanic descent, being Latina, has its own set of struggles that in some ways mirror, but at the same time, are completely different than those of a Black girl." Black women and particularly caregivers of students were mentioned by participants as the ultimate experts and the key decision-makers to positively influence the participation of Black girls in informal STEM learning. Now, I turn to participants' idea to also include industry professionals as extended group PLC members.

Industry Professionals

Beyond the job roles held in this temporary PLC, many participants thought it was important to invite *industry professionals* from industries beyond STEM as *extended group* members of their ideal PLC. They could also be involved in reading empirical research, PLC dialogue, reflections, and the *expansive* PD recommendations that lead them from *big ideas* to *promising practices* and *quick wins*. It was suggested that SMEs get invited to the PLC meetings less frequently than the Core Group to share opportunities for the PLC that may reach beyond the STEM and Education sectors. Red* suggested a "supporting cast" of experts in event operations and logistics, travel agents, bookkeepers and accountants, intellectual property attorneys, IT support, research librarians, in-person researchers, and key points of contact in the PLC who

"know stuff that we don't even always know to ask about." For example, Red* mentioned that if she was working on a program observing turtles, a travel agent might say, "There are really inexpensive trips available to Costa Rica right now where you and a team of up to nine people could go for under X amount of dollars and you could go and look at the turtles there because they have a lot more turtles there." Moxie* also suggested that the PLC include "people with financial backgrounds" like CFOs and legal experts like patent attorneys to ensure comprehensive planning.

Although they are not directly involved with student learning, Khalil mentioned giving an optional invitation to those involved with STEM exhibits at museums and tour guides. He said, "I think having that group and having that many different perspectives, helps when I hit a roadblock." For example, having a space to discuss differences between theory and practice, and providing alternative solutions that might work in practice would help him be a better coach and better teacher. Khalil was undecided whether to invite School Board Representatives like superintendents and council members because they are usually two or three degrees away from the actual work in practice. SMEs were discussed more generally; however, a specific job role rose to the top among participants, a Data Scientist.

Data Scientist

For some participants (Red*, Charles, Laila, AJ*, Daniel), it was particularly important to include a data scientist in the PLC. Red* is a data scientist and suggested that "getting some data scientists in the mix may help our PLCs design better programs, projects and research studies, and also organize their data in a way that is not a nightmare for them later on." She added, "data scientists can look at the breadth and depth of data that we're collecting and suggest ways to organize it that will make it much easier to be able to use it to answer questions later… and

sometimes data scientists can look at the data that we're collecting and say, 'Did you realize that you're walking away from some valuable data that you're not collecting?'"

Without explicitly calling for a data scientist, Charles recommended that the PLC include the types of people "who could develop a plan, an academic plan, a curriculum". AJ* also highlighted her need for help with determining goals for the PLC, which she thinks could be addressed by PD. When the PI mentioned that other participants talked about a data scientist who could help the PLC determine goals, AJ* responded, "That would be amazing!", and added that her fiancé is a data analyst who is responsible for "visualizing data and breaking it down so that it's digestible and seeing where the holes are". Combining their points, a data scientist could be an integral PLC member who can help determine the goals, metrics, and key performance indicators, so their importance is communicated to the PLC members. Next, I present the findings on participants' recommendations for Why? - **operating conditions** that will support their ideal PLC.

Finding #8: Why is this Framework suitable? Operating Conditions for their Ideal PLC

When participants were asked, "What more do you need to know to make a Professional Learning Community workable in your setting?", they identified five important operating conditions that would contribute to making an ideal PLC for informal STEM learning in San Diego County. These supports were both necessary for the individual PLC member, as well as their organization or institution. When Laila was asked what more she needs to know to make a PLC workable in her setting, she highlighted the need for clear expectations regarding time commitment, financial contributions, meeting location, and levels of cross-organizational participation or leadership obligations within the community. Joy likened the PLC time commitment to a Board or advisory committee that has a two-year commitment, and she

suggested the importance of clarifying these details to ensure the successful implementation and sustainability of the PLC.

Square* talked about the structure of her ideal PLC and said, “I feel like it has to be something that can be sustainable, and generated from within the group, and revisable”. Square* recommended that the PLC have “an iterative process where you go around like a design wheel, where you have an evaluation point, at least annually, where you can review how successful certain elements are and redesign it.” She added, “If things are not working, then change them, because that’s the other thing, if we’re doing it as a community and grassroots thing, we can be nimble. We don’t have to wait for permission from a federal funder or something. You can just do what’s right for the community right now.” Combining participants’ perspectives, the five main operating conditions needed in an ideal PLC are: (8.1) Foundation of Shared Goals, (8.2) PLC Meeting Frequency and Modality, (8.3) Building Relationships, (8.4) Organizational Commitment, and (8.5) Logistical Planning.

Finding 8.1: Foundation of Shared Goals

According to participants, the first, and most significant, operating condition of their ideal PLC was having *shared goals* amongst PLC members. Research suggests that PLC members can effectively determine *shared goals* that directly address improving student learning (Fulton & Britton, 2011; Townley, 2020). When asked, “What more do you need to know to make a Professional Learning Community workable in your setting?”, more than half of the participants (Square*, Moxie*, Red*, June, Joy, Daniel, Laila, Victor) highlighted the importance of having a *shared goal*.

When it comes to participants determining *shared goals* for the PLC that could improve student learning, some participants mentioned that they had a desire to determine *shared goals*

collaboratively with the rest of the PLC members. Joy thought of PLC goals in relation to this study's target audience of Black girls and said:

> [I would want to] know the group's expectations as we got to know each other more, or even setting [expectations] up at the beginning [to understand] people's desired outcomes, [and] what's important for them when discussing topics about engaging Black girls in STEM for the PLC specifically.

As it relates to Joy's job as a Program Manager, she would want more specific knowledge or have discussions around engaging Black girls in STEM in Kindergarten through 2nd grade, along with their experience in higher education, so she can be aware of her students' pathway in STEM "and how all of the organizations can come together to help support the retention and sense of authentic belonging in STEM for Black girls." Thus, to analyze more thoughts on *shared goals* for the PLC, I examined participants' *personal goals* related to improving student learning. Some of their *personal goals* are shared below as a starting point for PLC members to define the PLC's *shared goals*.

In determining *shared goals* for the PLC, Square*, Executive Director at The League, proposed that the PLC could identify and analyze specific challenges related to diversity when she said, "This PLC can help to have that really articulated and unpacked… it's empowering, and it helps to have the courage to do the hard things." According to Square*, when all diversity issues are lumped together, it makes the problem "worse for the person who's in an intersectional set of challenges". She added, "I feel like over the last three to four years, there's been a lot of shifting in the discourse… I think it's a good place to be starting out: developing these communities and giving yourself the space and the permission to really dig into what needs to happen."

Another *shared goal* of the PLC could be to empower its members to advocate for positive systemic changes in education. June, an Executive Director at Science To-Go, a science

education nonprofit, designs curriculum and teaches informal education within schools. June's goal is to "make a dent in the entire San Diego Unified School System in five years", and she would like to work with other PLC members to do so. According to June, participating in this PLC encouraged her to think about how to communicate, and identify her discomfort in standing strong in her beliefs. June mentioned that tapping into those feelings during this study's PLC was very beneficial for her as she launches advocacy and professional development modules discussed in her grant proposals. June stood firm that making changes in pedagogical approaches at the school system level could be a *shared goal* of the PLC.

In reference to a more practical *shared goal* of the PLC, Red* discussed how the PLC can "raise funds for the work that [PLC members] do to support and foster this community". Red* claimed that having resources beyond what the employer provides asserts independence from relying solely on the employer. For example, Red* suggested that the PLC provide travel funds for members to attend PLC conferences or workshops, so the members do not have to rely on employers or their own personal funds to pay for their travel. According to Red*, PLC members can be seen as "well-networked", with professional skills, social capital, and resources that make them a powerful force in their field aside from the organization. Red* thought this *shared goal* of raising funds through the PLC would remind its members that "Our employers do not own us!"

In summary, having a *shared goal* is the most significant and foundational operating condition of an ideal PLC for informal STEM practitioners. While each participant may have different *personal goals* for participating in the PLC, it is valuable for the PLC members to come together and determine a *shared goal* for the PLC. Upon this foundation of a *shared goal*, the following sections of this finding discuss additional operating conditions that make this a

suitable design for an informal STEM PLC framework. The next **operating condition** is the frequency and modality of the PLC.

Finding 8.2: PLC Meeting Frequency and Modality

According to participants, another factor necessary for an ideal PLC for informal STEM education in San Diego County is meeting frequency and modality. When asked what he would need to know to make a PLC workable for him, Charles responded that "timing and scheduling is the biggest [factor]". When asked about the frequency (how often) and modality (in-person, online, neither, or both) of their ideal focus group, the benefits of each immediately surfaced. As we will explore in more depth in this finding, participants' views aligned with the research and mostly centered on having PLC meetings occur on a regular basis (Fulton & Britton, 2011), with some interesting comments related to utilizing both online and in-person platforms to accommodate diverse learning preferences and schedules.

The majority of participants recommended a combination of quarterly in-person meetings and monthly virtual meetings, while others suggested more frequent virtual meetings with less frequent in-person meetings. Technology can support the goals of the learning community in innovative ways. Because members of virtual PLCs do not share common schools or students, they typically feature more discussion of pedagogy, its application, and collaborative materials (Fulton & Britton, 2011). Although this design is not ideal for all teachers, there is still value in breaking teacher isolation to confer, collaborate, and share (Fulton & Britton, 2011). This study was done completely virtually with the use of technology, and still participants mentioned the advantages. For example, although Matilda had a preference for in-person meetings, she said that she could "for sure commit to something on Zoom" due to practicality. For Matilda, the frequency of virtual meetings would ideally be monthly (if 2-3 hours long) or twice a month (if

1-hour long). She noted that if the meetings were held in person, she would still like them to occur monthly.

Many of the participants (Square*, AJ*, Laila, Charles, Khalil, Victor, Coco) recommended in-person meetings, with some who recommended that the in-person meetings occur quarterly. The most popular combination of meetings for the PLC was quarterly in-person meetings and monthly virtual meetings. Square* emphasized that PLC members can "experience the full range of communication", and said, "So much communication is about more than words and even more than facial expressions, so you have to have some in-person opportunities, but it makes it so much easier if the grunt work can be done online". Laila suggested that the PLC have a leadership team that would meet monthly, and organize a quarterly mixer or event to foster networking among all participants. Charles expressed his desire for monthly meetings to refocus, recharge, and recalibrate with other PLC members. Since Charles lives long-distance, he suggested meeting online monthly (one hour in the daytime) and in-person quarterly (in the evening) as the easiest for him to participate.

Instead of meeting in-person on a quarterly basis, Victor and Khalil both preferred to meet in-person three times per year. Victor suggested in-person meetings occurring three times per year, right before school starts, during the school year, and in the middle of spring. Victor also recommended for other meetings to occur virtually depending on scheduling considerations with a frequency of every three weeks since every two weeks is too frequent, and monthly meetings make it hard to maintain momentum. Similarly, Khalil suggested having more structured, organized and strategic in-person meetings or conventions at the beginning (August/September), middle (December/January, not including winter break), and end of the school year (May/June) closer to the weekends on a Thursday or Friday. Khalil recommended

that monthly virtual meetings be more informal and repetitive earlier in the week on a Tuesday or Wednesday. He added that the PLC members could set goals and objectives and report back on the results at the following monthly meeting. Khalil also mentioned that informal meetings outside of the structured sessions may be beneficial and said, “There will be a lot more informal meetings than formal meetings for sure.”

A few of the participants (Red*, Daniel, Coco) recommended that the PLC meetings occur more often than monthly. In addition to monthly presentation forums, Red* proposed bi-weekly working meetings for educators to collaborate on specific tasks between the presentation meeting, or ad hoc meetings to address a time-sensitive topic. Coco discussed the frequency of meetings, with monthly or bi-monthly gatherings for the larger group and meetings every two weeks for working groups “based on what they’re trying to accomplish”.

Daniel felt like the duration of the focus groups “flew by” with “so much more to be said”, and wondered if longer or more frequent meetings weekly or twice monthly “would allow for deeper conversations or ones where we can build off the conversations that already happened because they were still fresh”. He also emphasized the value of frequent meetings to stay on top of readings and avoid procrastination. Daniel concluded that his ideal PLC would have in-person weekly meetings due to a better flow of conversation and human connection. He acknowledged potential logistical barriers associated with frequent face-to-face meetings, but thinks that in-person interactions are better for discussing emotional topics, and allow for different modes of expression. Daniel discussed his challenges in this study with virtual communication and how it delayed him in chiming in during conversations. He reflected back to when he designed PD for teachers, and they did a gallery wall using big Post-it paper with a question on top where

"everyone writes their response on that and then can see other people's responses" to get more ideas and thoughts.

Compiling their points, an ideal PLC for informal STEM Educators and Educational Leaders in San Diego County should meet consistently, but the frequency and modality (in-person or virtual) can vary depending on the needs of the PLC members. The popular opinion among participants is a combination of quarterly in-person meetings and monthly virtual meetings, while others suggested more frequent virtual meetings or less frequent in-person meetings. Ultimately, the ideal PLC format should be determined collaboratively by the PLC members themselves. I turn now to the next significant operating condition of their ideal PLC, Relationship Building.

Finding 8.3: Building Relationships

The next operating condition that was important to participants was the ability to *build relationships* with its members. According to research, ensuring an aligned culture and communication of educational leaders can improve student pursuit of STEM disciplines (Kirst & Venezia, 2004). Several participants, like Joy, emphasized the importance of *building relationships* within the PLC when she said, "Relationships are a huge resource." She mentioned building relationships through the PLC, that lead to valued relationships and "brave space type of conversations" where "everyone's more likely to learn, have more discussions that are innovative, or tackle difficult topics".

Participants mentioned that *building relationships* in the PLC could be healing for them. When asked how the PLC could help his organization, Victor replied, "I wonder if there's more space for the tougher conversations about what we do in our company." He added:

> I think the opportunity for me would probably be to have a space to talk through more of these situations and maybe even just more of my personal side of it because I think that's the tough part. I think my team hears a lot of this frustration sometimes and I don't think that's actually the best way to do it, because a lot of that is actually just me wrestling with myself. That's better done in an external community of people that do have genuinely just an outside lens. What I would want… it almost feels like a support group. It's like Alcoholics Anonymous for people doing equity work.

Along those lines, Charles shared his sentiment on the importance of *building relationships* within the PLC when he is struggling and needs support when he said, "I would like [the PLC] to be a space where we could bring the things we're struggling with, that we're trying to create, or we're trying to implement to the table to get that support from the PLC members". Charles emphasized the value of having access to professionals in the PLC for fruitful thought exchange, connection, and collaboration opportunities that can lead to innovative ideas for growth where each member takes turns to get "support of all the minds" of PLC members. Similarly, Square* appreciated being able to openly address issues related to "anti-black racism and misogyny" within this temporary PLC and said, "It's not just enjoyable, it's healing."

Effective PLCs can *build relationships* among its members. These relationships create a safe space for open communication and finding support when working in silos. Participants' ideal PLC also allows members to connect with professionals outside of their organizations, expanding their network and outreach capabilities. Thus, fostering an environment to *build relationships* that are supportive in nature is essential to the design of a PLC for informal STEM learning.

Finding 8.4: Organizational Commitment

Another **operating condition** necessary for participants' ideal PLC was to have *organizational commitment.* Research suggests that PLCs encourage a collaborative culture of

shared ownership, responsibility, and success among teachers and for each student (DuFour, 2004). When asked what more she needed to learn to create a PLC, Laila emphasized the importance of long-term *commitment* from institutions when she said, "I'd want to make sure that the institution was really committed to seeing it through long term before I did something and have it fizzle out a year later. I want to make sure there's deep commitment, not just surface level commitment." When asked about her ideal PLC, Square* also mentioned *organizational commitment* when she said, "...not only are the individuals bought into it, but the organizations that they come from are also bought into it, and [PLC members] can be given time out of their working life and be expected to bring stuff back into the organization somehow to make it bigger than just the individuals."

Organizational commitment can also involve money as a literal investment in its staff. Red* compared the PLC to an Employee Resource Group (ERG) in that it can influence Human Resources (HR) and Chief Financial Officers (CFOs) in "baking time and money into each quarter and each budget so that people can be scheduled and can be funded to go and participate in conferences/ workshops and complete the loop to bring back what they gain from that participation and apply it in the environment that matters to the company." Red* added that to make it easier to receive *organizational commitment*, the PLC could support its members by providing templates and data analysis tools that show the benefits of participating in a PLC to members' organizations. Similarly, Square* mentioned that the PLC could gain *organizational commitment* by providing communications of the return on investment to "show how [the PLC] is beneficial to their organization". Square* said, "You have to be able to demonstrate the kind of feedback loop of how [PLC members] are going to be able to bring back learnings, best practice… It is a long-term investment, but it's definitely going to pay off."

According to participants, in addition to individual commitment, their ideal PLC requires buy-in and *organizational commitment* from their employers. Organizations should invest time and resources, such as funding for conferences and workshops, to support PLC members' participation. Benefits obtained from attending professional development events can then be applied within the organization, improving its overall effectiveness. By demonstrating this return on investment through clear communication, participants suggested that organizations can more easily justify their long-term commitment to PLCs. Next, I turn to the last **operating condition** that makes this informal STEM PLC Framework suitable, an advanced consideration on logistical planning.

Finding 8.5: Logistical Planning

The final **operating condition** that participants mentioned for their ideal PLC was to address logistical challenges ahead of time through *logistical planning*. In her own final interview, AJ* replied that she is curious about the "smaller *logistics*" including dues to pay and the required workload. She asked, "What do I need to do to help support the Professional Learning Community? What can I bring to the table instead of only taking from it?" AJ* was also curious about the logistics and transportation needs for in-person meetings such as a host meeting site or rotation of sites.

Although Square* is in the Executive Director role, which she claimed does not have many funding limitations, she suggested that the PLC can consider *logistical planning* for resources to make the PLC "feasible for [other members] to either take time out of their working life or their family life". The resources that Square* considered include funding for childcare, transportation, and other support services that can remove barriers to participation. Square* said that it is important to think about "addressing those challenges from the beginning". Square*

mentioned that it may be beneficial to explore funding opportunities from sources such as the City of San Diego, County of San Diego, or a membership fee.

When further discussing financial contributions, Laila emphasized the need for *logistical planning* and transparency about how the money is used. She suggested different levels of financial contributions for an annual membership, or a membership in exchange for pro-bono expertise (data scientist, statistician, payroll), or a membership in exchange for allowing students of PLC members to participate in events at no-cost. Laila suggested involving diverse sectors including large and small nonprofits and for-profits to provide depth and breadth of expertise and backing for grant funding with a culture of inclusivity. Laila reiterated the necessity of communicating financial expectations for PLC members or organizations, and also mentioned other *logistical plans* for the PLC to provide partial scholarships or internships to benefit students within their individual programs.

According to participants, an ideal PLC needs to address logistical challenges upfront. Some solutions to these challenges include scheduling meetings with advance notice, determining a location for in-person meetings, and communicating financial contributions. For some PLC members, overcoming logistical hurdles may require resources like childcare or transportation assistance. These resources can be funded by grants or membership fees, provided financial transparency is maintained.

This finding answered the question "*Why is this Framework suitable?",* and highlighted five key **operating conditions** for an ideal PLC for informal STEM education: *shared goals*, *meeting frequency and modality*, *building relationships*, *organizational commitment*, and *logistical planning*. I will now provide a summary of the Framework as described in this chapter.

Summary

What? Participants suggested **enhancements** for the PLC design including, *reading research*, knowledge sharing through *dialogue, reflection*, and aspirations for *collaboration* within their ideal PLC. They inquired about research that could be aggregated based on their interests. For focus groups, participants preferred topics related to improving their practice that could be discussed with a growth mindset. Finally, while reflections were seen as valuable, participants had no strong preference on how to conduct them, and could be a point of discussion once the PLC is established.

How? According to participants, the PLC could use more **effective PD** learning approaches that are *research-driven*, *peer-led*, and *project-based*. Participants saw themselves not only benefiting from reading research and the expertise of others, but also contributing their own knowledge and conducting research.

Who? Participants suggested **human resources** for their ideal PLC. They desired that the PLC be led by a well-respected and trusted *Facilitator* who can provide crucial leadership, guidance, and credibility. The *core* group of like-minded PLC members will establish a foundation of collaboration and shared goals. Additionally, participants thought the PLC will benefit significantly from an *extended* cabinet composed of representatives from the PLC target audience, notably caregivers of Black girls, and Subject Matter Experts (SMEs) including a Data Scientist.

Why? In this study's temporary PLC, having a foundation of a *shared goal*, the most crucial **operating condition**, provided direction and motivated members. Monthly virtual meetings keep participants connected, and quarterly in-person meetings strengthen their connection. Building relationships fosters open communication, collaboration, and professional

development. Gaining buy-in from participating organizations through investment in resources and feedback of the return on investment strengthens the PLC's sustainability. Finally, addressing logistical challenges upfront, such as scheduling and child care assistance, ensures equitable participation. By prioritizing these operating conditions, PLCs can create a supportive environment for educational leaders to tackle challenges, develop innovative solutions, and ultimately improve STEM education for their communities.

CHAPTER 6: DISCUSSION

This temporary PLC was reported to positively impact participants' understanding and ability to address racial inequity and create community with other informal STEM practitioners. This concluding chapter reiterates the problem, reasserts the purpose of the study, research methodology, and conceptual framework theories which guided the study. Then, this chapter will review key findings, and discuss the study's implications, and recommendations for future research.

The United States faces a shortage of qualified STEM workers, while Black women and girls are leaving the STEM pipeline due to systemic barriers and negative educational experiences that they encounter everyday (King & Pringle, 2019). Black girls are trailing behind their peers in science and mathematics, narrowing their career options to fill the shortage of qualified STEM workers (King & Pringle, 2019). However, research shows that interventions can start early to keep Black girls in STEM (McPherson, 2014). While professional learning is known to improve student achievement, there is a gap in understanding how to design a PLC to specifically empower educators and educational leaders in informal STEM settings. This study invited informal STEM practitioners to participate in a temporary PLC, and then asked them for recommendations on the design of their ideal PLC to specifically support Black girls in informal STEM settings.

This study used a Participatory Action Research (PAR) design to understand educators' perspectives on a PLC for supporting Black girls in STEM by participating in one. The participatory nature means that the participants can develop a community that may turn their practice into action (Kemmis et al., 2014). In this study, each focus group functioned as a PLC meeting. The meetings were organized by the themes presented in the review of the literature:

Big Ideas About the Underrepresentation of Black girls in STEM, Promising Practices to Empower Black Girls' STEM Identity, and Collaboration and Professional Learning Communities. Participants read research materials, engaged in three focus groups, and participated in interviews. The data sources for this qualitative study included: self-study questions, pre- and post- individual interviews, reflection questionnaires, focus group discussions, researcher memos, and researcher post-interview summaries member-checked by each participant. Data analysis involved thematic analysis and tapped Critical Race Feminism to identify themes as participants considered race, gender, and class factors in their own work.

The integration of Critical Race Feminism helped participants appraise their professional practice in the broader social justice movement. An abundance of empirical research shows how the intersectionality of race, gender, and class disparities affect Black girls' pursuit of STEM learning (Collins et al, 2020; Dixon-Payne, 2022; King & Pringle, 2019; Lindsay-Dennis, 2015; Pinkard et al., 2017; Pollock, 2017). Critical Race Feminism proved to be a useful framework to engage informal STEM Educators and Educational Leaders across broad racial and gendered experiences. Therefore, it is important to consider Critical Race Feminism as a theoretical framework for the design of a future PLC for informal STEM practitioners to engage *big ideas* around race, gender, and class in their own work, and evolve their learning into *promising practices* and *quick wins* that may shape the lives of Black girls and the lives of other underrepresented intersecting identities for future generations to come.

Conclusions and Implications

The research participants of this study defined a Professional Learning Community (PLC) as a collaborative group of educators and professionals working together, sharing knowledge and experience on deep issues in their work, and supporting each other on shared

goals to improve their practice and ultimately improve student or organizational outcomes. Participating in this study's PLC empowered informal STEM practitioners to share responsibility for addressing STEM attrition, create connections, and learn from each other. Participants noted that this study's PLC usefully had them read research, discuss it in focus groups, and reflect on it, which led them from *big ideas* to *promising practices* and *quick wins* that could actually work to improve student outcomes for Black Girls in informal STEM. This resulted in participants naming several solutions to improve outcomes for Black girls in STEM: building community networks that include families, Black women, and role models; creating safe spaces for them; strategically recruiting and engaging them; fostering belonging and a sense of community; recognizing and combating stereotypes; and leveraging collaborations between formal and informal STEM education.

The ideal PLC for informal STEM education practitioners in San Diego County will allow PLC members to learn by reading empirical research, having dialogue with one another, and engaging in self-reflection along with growing opportunities for collaboration. Their ideal PLC will have a Professional Development learning approach that is research-driven, project-based, and peer-led. Their ideal PLC has members who include a trusted Facilitator, a core group of members (STEM educators, administrators, principals, nonprofit leaders, real-world industry professionals, researchers, program designers and practitioners) with geographic diversity, and an extend group of subject matter experts that includes representatives of the target audience, a data scientist, and industry professionals (statistician, payroll, CFO, legal experts, travel agents, bookkeeping and accountants, intellectual property attorneys, IT support, research librarians, in-person researchers). The essential operating conditions for their ideal PLC are: it is goal-oriented, has a flexible meeting format (quarterly in-person meetings for the core group, and

monthly virtual meetings for the extended group), builds relationships, each member has organizational commitment, and that the logistics are planned in advance.

The remainder of Chapter 6 presents conclusions, implications, and suggestions for future research. There were eight broad conclusions for informal STEM educators and educational leaders drawn from this study. The first four conclusions relate to experiences with professional learning and promising practices to improve student outcomes for Black girls in STEM. The last four conclusions feature key components of a PLC designed to advance informal STEM learning for Black girls. Each set of conclusions are followed by their Implications, and overall recommendations.

Chapter 4 Conclusions

1. Including **reading** empirical research grouped by theme, **dialogue** in focus groups, and room for **reflection** can lead PLC members from *big ideas* to *promising practices* and *quick wins* to improve student outcomes for Black Girls in STEM. Also, participating in a PLC can increase their desire to learn from one another by sharing successes and challenges, and by allowing them to collaboratively rethink their approaches to informal STEM education. The study itself fostered a collaborative spirit, with participants feeling empowered to work together.
2. Focusing on a theme, such as a target audience of Black Girls, helped to guide the PLC dialogue. Participating in this study led practitioners of informal STEM education to professional learnings that can empower Black girls' student achievement such as: embracing **community networks** of role models for Black girls, creating a **safe space** for Black girls, strategically **recruiting and engaging** with Black girls, **recognizing and**

addressing stereotypes about Black girls, building a sense of **belonging and a community** for Black girls, and collaboration between **formal and informal learning**.

3. Participating in the PLC fostered a sense of shared responsibility for addressing STEM attrition, allowing informal STEM practitioners to see their individual contributions as part of a larger solution. The PLC also broke down silos, fostering connection and learning opportunities with like-minded individuals. Engagement within a PLC can encourage informal STEM practitioners to embrace data-driven approaches to communicate and continually improve their practice.
4. For informal STEM practitioners, the definition of a PLC is clarified after participating in one. They defined a Professional Learning Community (PLC) as a collaborative group of educators and professionals working together, sharing knowledge and experience on deep issues in their work, and supporting each other on shared goals to improve their practice and ultimately improve student or organizational outcomes.

Chapter 4 Implications

This dissertation is grounded in the critical need for interventions that address the underrepresentation of Black girls in STEM fields. Existing research suggests that the underrepresentation of Black girls in STEM classrooms can lead to feelings of isolation, alienation, and tokenism (Burnett et al., 2023; King & Pringle, 2019). Unfortunately, schools can become inhospitable environments for these students, sending mixed messages about femininity and achievement while holding them to unreasonable standards (Carter Andrews et al., 2019). While formal education plays a vital role, a significant portion of learning happens in informal settings throughout a person's life (Bevan et al., 2013; King & Pringle, 2019). Informal STEM learning emerges as a promising approach to counter these challenges. By providing alternative

learning spaces and fostering a sense of belonging, informal STEM programs can increase access to learning opportunities and address educational inequities, ultimately broadening participation in STEM for all (King & Pringle, 2019; Townley, 2020).

This dissertation identified a critical gap in the literature: a lack of research on how to design experiences that help educators and educational leaders *themselves* design informal STEM learning experiences to support Black girls. While there is *limited* research about Black girls in STEM, this study shifts the focus to informal STEM practitioners themselves to determine their needs for professional learning. Furthermore, it investigated how to connect opportunities across San Diego County and leverage the network within informal STEM to make sense of empirical research and determine their own solutions. This aligns with research suggesting that improving teacher quality is key to increasing STEM interest among women and underrepresented students (Birney & McNamara, 2019).

Research suggests five core elements for a strong PLC: reflective dialogue, focus on student learning, interaction among teacher colleagues, collaboration, and shared values and norms (Kruse et al., 1994, Townley, 2020). The first three elements were identified in this study, and the final two were mentioned as opportunities for a future, ideal PLC. Including **reading** empirical research, **dialogue** in focus groups, and room for **reflection** can lead PLC members from *big ideas* to *promising practices* and *quick wins* to improve student outcomes for Black Girls in STEM. These elements align with the need for informal educators to shift their professional learning conversations beyond program logistics, delving deeper into pedagogy and praxis to improve student learning (ACER, 2019; Tran et al., 2013). This PLC provided a platform for informal STEM practitioners to share valuable learning experiences, advice, and mentorship, promoting their individual and collective growth.

While participating in this study's PLC, informal STEM practitioners realized the potential of PLCs to break down silos within informal STEM education, while also encouraging them to leverage research-driven approaches for communication and improvement of their practice. This aligns with the growing emphasis on PLCs in education - a trend driven by the shift away from isolated classrooms and towards a more interconnected educational system that fosters collaboration (Townley, 2020). By providing a platform for educators to connect and share their in-practice experience, PLCs can empower informal STEM practitioners to create a more effective and equitable learning environment for Black girls.

The research design, which included prompting participants to define a PLC themselves, brought to light the tangible benefits of belonging to such a community. These definitions can be a powerful tool for promoting PLC participation in informal STEM education settings. By emphasizing the specific advantages outlined in the participant definitions, such as collaboration, shared learning, and support for continuous improvement, messaging around PLCs can resonate more effectively with educators rather than simply using the term "Professional Learning Community" itself, which may hold less familiarity within informal education contexts.

Chapter 5 Conclusions

5. An enhanced PLC design for informal STEM practitioners lends itself to its members gaining knowledge and skills with and from each other, highlighting collaboration as a future benefit of their ideal PLC. They envisioned collaborating with organizations that serve Black girls and leveraging each other's strengths to create lasting change.
6. Participants did not only want to read and discuss research, but also desired a PLC where they could learn from and with each other through an expansive view of Professional Development. Other aspects of Professional Development in a PLC for informal STEM

practitioners could include **creating research** through equity & impact reports, **peer-led cross training**, and **project-based learning**.

7. Inviting the right members to participate in a PLC is key: a well-trusted facilitator can recruit PLC members even if the members do not know what to expect. A core PLC group with diverse career stages and geographic representation can offer a comprehensive understanding of the complexities within informal education. An Extended Group of PLC members could include a data scientist, and other Subject Matter Experts. Additionally, representatives from the target audience could be present, including caregivers. Participation from this extended group of PLC Members can ensure the learning experiences are not only culturally responsive, but also aligned with the needs and interests of the PLC's target population.
8. The operating conditions for an ideal PLC in informal STEM education according to participants are: be goal-oriented, foster relationship building, have an organizational commitment, and be effective at logical planning. The PLC can have a flexible meeting format with consistent and iterative sessions that are held quarterly in-person and monthly virtually.

Chapter 5 Implications

This dissertation offers a roadmap for designing effective PLCs within informal STEM learning environments that provide learning experiences educators and educational leaders want and need. By leveraging the findings presented here, informal STEM practitioners can create learning communities that are efficient, impactful, and create a culture of success (Fulton & Britton, 2011; Malcom et al., 1976; McClafferty et al., 2009). This research can reduce wasted time and effort during the initial stages of PLC development, allowing for a more streamlined

approach. Furthermore, the effectiveness of a PLC can still be achieved even if specific aspects deviate slightly from the proposed framework (Kezar et al., 2017; Townley, 2020). For instance, PLCs lacking some ideal members can identify and integrate these individuals as the community evolves.

The research also highlights the potential for PLCs to drive broader systemic change. This study aligns with research highlighting the power of networked communities with strong leadership (Kezar et al., 2017). Such networks can not only promote reform within STEM education but potentially expand their influence to encompass broader educational reform efforts (McClafferty et al., 2009). Effective PLC leaders play a critical role in establishing and sustaining a stable and supportive environment that attracts, retains, and cultivates future leaders (Khalifa et al., 2016). This collective leadership can ultimately lead to more effective learning experiences for Black girls in STEM fields (Fulton & Britton, 2011), fostering a culture of success with long-lasting, sustainable improvements (Hargreaves, 2003).

The rise of PLCs aligns with the shift in educational philosophy, moving away from isolated classrooms and towards interconnected systems (Townley, 2020). This dissertation offers a unique perspective on the specific elements that contribute to successful PLCs in informal STEM settings. Existing research on successful PLCs, highlights the importance of strong leadership support, shared goals, and a commitment to self-directed reflection (Fulton & Britton, 2011; Townley, 2020; Leithwood et al., 2008; Young-Wallace et al., 2020). Participants in this study echoed similar themes but far more specifics, including the need for human resources, goal-oriented structures, and research-driven professional learning that incorporates reading, dialogue, and reflection. This focus on shared accountability for learning outcomes aligns with broader research on effective learning communities (Townley, 2020).

This work on building a PLC to advance informal STEM learning has revealed great benefits for serving practitioners and students in this field (Heimlich et al., 2021). Evidence from self-study questions, pre- post- interviews, focus groups, and written reflections reveal tremendous interest in the design of a PLC that would be ideal for them to attend, especially if resources become available. The framework proposed in this study resonated with participants, particularly the potential for increased access to resources. A key takeaway is the strong desire among practitioners to learn from each other across career stages, highlighting the value of a collaborative PLC environment. Research suggests that PLCs, where educators learn from each other and engage with real-world applications, can boost both educator confidence in STEM fields and student interest in these subjects (Birney & McNamara, 2019; Townley, 2020; Heimlich et al., 2021). Unlike isolated learning settings, PLCs provide a space for adult learners to actively process information, collaborate, and translate theory into practice (Heimlich et al., 2021). Additionally, effective PLCs consider the unique needs and backgrounds of educators, the content being explored, and the overall learning environment (Heimlich et al., 2021). By emphasizing collaboration and real-world application, PLCs can offer a more effective approach to professional development for informal STEM educators.

Furthermore, this study revealed two key factors that may contribute to the potential limitations of applying traditional in-school PLC models to informal STEM educators. First, many informal STEM educators operate in silos within their organizations and are not familiar with the concept of PLCs. Second, traditional professional learning often does not consider issues of race, racism, and racial inequities within educational settings and society (Pollock & Matschiner, 2024). This dissertation proposes an alternative learning approach: expansive professional development (PD) that is research-driven, peer-led, and project-based, which also

tackles big ideas and concrete application alike, and grapples head on with issues of race and racism. This approach can address the specific needs of informal STEM educators, enhance their professional learning, and ultimately contribute to creating a more inclusive and successful learning environment for Black girls in STEM fields.

Participant feedback revealed additional considerations for operating conditions to sustain a PLC that were not considered in this study's PLC design. One key finding was the importance of including representatives from the target audience – Black women and caregivers of Black girls – in future PLCs. Parent involvement strategies could be incorporated into the PLC's framework to create a more comprehensive support network for Black girls in STEM (McPherson, 2014). Additionally, participants identified the value of involving subject matter experts and data scientists. These individuals could offer specialized knowledge and data-driven insights to inform PLC discussions and activities (DuFour, 2004; Townley, 2020; Hargreaves, 2003; Hord, 2004). By incorporating these additional elements – an extended member group and a focus on parental engagement – future PLCs can be designed to be more comprehensive and sustainable.

Lastly, organizational commitment, evidenced by the support, guidance, and resources provided by educational leaders, is a critical operating condition for sustaining effective PLCs for STEM educators (Fulton & Britton, 2011). Strong, supportive leaders with clear communication are essential for facilitating cultural change within organizations (McClafferty et al., 2009). While the impact of educational leaders on student achievement is typically indirect, educational leaders play a vital role in shaping a culture that prioritizes teaching and learning, ultimately supporting students through their staff and program design (Biddle et al., 2018; Buttram & Farley-Ripple, 2016; Leithwood et al., 2008), which is why they were also included

in this study. Thus, to foster organizational commitment, the PLC can establish strong connections with educational leaders, securing their buy-in and return on investment for the allocation of necessary resources such as educator time and support.

Recommendations

Supporting Black girls to pursue and remain in STEM is a crucial societal need, and informal education is one crucial place to do such work. By learning from informal STEM programs that support Black girls' science identity, formal science education can be reimagined. Also, existing research indicates that practitioners of STEM learning need to be developed and supported to in turn support Black girls through the STEM pipeline (Fulton & Britton, 2011).

This dissertation contributes to the ongoing effort to advance equity in science education through transformative action, research, and practice (King & Pringle, 2019). It proposes a framework for a PLC specifically designed for informal STEM practitioners to advance informal STEM learning for Black girls. The findings demonstrate the potential of PLCs within and across informal STEM learning organizations, suggesting broader applicability beyond traditional school settings. Further work is needed to effectively utilize this framework, and caution should be taken in generalizing these results.

This dissertation lays the groundwork for future research on PLCs and their impact on addressing *racial* and *gender* inequities in informal STEM learning. Several promising avenues for future research exist. First, replicating this study with participants from a different background could provide valuable insights. For example, studying Black women leading informal STEM organizations for Black girls could offer a unique perspective. However, this audience may need to extend beyond San Diego County, so geographical considerations such as time zones and participant availability may require adaptations. Second, the research could be

adapted to explore the needs of other underrepresented groups in STEM, such as Latina girls, the deaf community, or specific age student groups - as suggested by participants in this study. To effectively adapt the PLC for a different target audience, one should consider tailoring the selection of empirical research articles and crafting discussion questions that resonate with their specific experiences and needs in STEM education. Finally, future research could examine how informal STEM practitioners utilize the proposed PLC framework to advance their organization's inclusion efforts. This study could involve facilitating a PLC with practitioners and documenting its impact on their programs.

Securing funding is required to replicate this research and to create such a PLC based on the proposed framework. Participants expressed enthusiasm for the PLC framework and they requested its implementation. While participants currently lack the capacity to lead a PLC due to existing workload demands, they acknowledge the crucial role of the facilitator and the need for external support. Securing funding from government agencies such as the National Science Foundation Advancing Informal STEM Learning (AISL) Program could support facilitators to develop and implement this PLC framework to move informal STEM organizations forward. Although securing funding for a dedicated facilitator is ideal, the PLC framework itself can still be implemented with a knowledgeable and committed volunteer to facilitate discussions. Ultimately, this collaborative and expansive approach to professional development can equip informal STEM practitioners with the knowledge and tools necessary to create transformative learning experiences for Black girls in STEM.

References

Alfred, M. V., Ray, S. M., & Johnson, M. A. (2019). Advancing Women of Color in STEM: An Imperative for U.S. Global Competitiveness. Advances in Developing Human Resources, 21(1), 114–132. https://doi.org/10.1177/1523422318814551

ACER (Australian Council for Educational Research). (2019). "The ACER Professional Learning Community Framework. The Australian Council for Educational Research." https://www.acer.org/files/ACER-PLCF-Information-Pack.pdf.

Baker, D. J., Arroyo, A. T., Braxton, J. M., Gasman, M., & Francis, C. H. (2021). Expanding the Student Persistence Puzzle to Minority Serving Institutions: The Residential Historically Black College and University Context. *Journal of College Student Retention: Research, Theory & Practice*, *22*(4), 676–698. https://doi.org/10.1177/1521025118784030

Bevan, B., Dillon, J., Hein, G., McDonald, M., Michalchik, V., Root, D., Miller, D., Rudder-Kilkenny, L., Xanthoudaki, M., & Yoon, S. (2010). Making Science Matter: Collaborations Between Informal Science Education Organizations and Schools.

Bevan, B., Bell, P., Stevens, R., & Razfar, A. (Eds.). (2013). *LOST Opportunities: Learning in Out-of-School Time* (Vol. 23). Springer Netherlands. https://doi.org/10.1007/978-94-007-4304-5

Biddle, K. A. G., Harven, A. M., & Hudley, C. (2018). Educational Leaders and Educational Agencies: Pre-K Through 12th Grade. In *Careers in Child and Adolescent Development*. Routledge.

Birney, L., & McNamara, D. (2019). The Curriculum and Community Enterprise for Restoration Science S.T.E.M. + C Professional Learning Model: Expansion and Enhancement. *Journal of Curriculum and Teaching, 8*(3), 122. https://doi.org/10.5430/jct.v8n3p122

Braun V., Clarke V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology, 3*, 77–101. doi:10.1191/1478088706qp063oa

Brickhouse, N. W., Lowery, P., & Schultz, K. (2000). What Kind of a Girl Does Science? The Construction of School Science Identities. *Journal of Research in Science Teaching, 37*(5), 441–458. https://doi.org/10.1002/(SICI)1098-2736(200005)37:5<441::AID-TEA4>3.0.CO;2-3

Burnett, M., Cooper, S., Butler-Barnes, S. T., & McCoy, W. N. (2023). Gendered Racial Stereotype Endorsement: A Theoretical Review and Implications for Black Girls' STEM Identity. *Journal of African American Women and Girls in Education, 2*(3). https://doi.org/10.21423/jaawge-v2i3a137

Burrows, A., & Slater, T. (2015). A proposed integrated STEM framework for contemporary teacher preparation. Teacher Education and Practice, 28(2/3), 318-330.

Burt, B. A., Williams, K. L., & Palmer, G. J. M. (2019). It Takes a Village: The Role of Emic and Etic Adaptive Strengths in the Persistence of Black Men in Engineering Graduate Programs. *American Educational Research Journal*, *56*(1), 39–74. https://doi.org/10.3102/0002831218789595

Buttram, J. L., & Farley-Ripple, E. N. (2016). The Role of Principals in Professional Learning Communities. Leadership and Policy in Schools, 15(2), 192–220. https://doi.org/10.1080/15700763.2015.1039136

Calabrese Barton, A., & Berchini, C. (2013). Becoming an insider: Teaching science in urban setting. *Theory into Practice, 52*(1), 21-27. https://doi.org/10.1080/07351690.2013.743765

Cantor, N., Mack, K. M., McDermott, P., & Taylor, O. L. (2014). If not now, when? The promise of STEM intersectionality in the twenty-first century. Peer Review, 16, 29-31.

Carlone, H. B., & Johnson, A. (2007). Understanding the science experiences of successful women of color: Science identity as an analytic lens. *Journal of Research in Science Teaching*, *44*(8), 1187–1218. https://doi.org/10.1002/tea.20237

Carter Andrews, D. J., Brown, T., Castro, E., & Id-Deen, E. (2019). The Impossibility of Being "Perfect and White": Black Girls' Racialized and Gendered Schooling Experiences. *American Educational Research Journal, 56*(6), 2531-2572. https://doi.org/10.3102/0002831219849392

Charleston, L. J., Adserias, R. P., Lang, N. M., & Jackson, J. F. (2014). Intersectionality and STEM: The Role of Race and Gender in the Academic Pursuits of African American Women in STEM. *Journal of Progressive Policy & Practice, 2*(3), 273–293.

Chen, R.-J., Daniels, E., & Ochanji, M. K. (2017). Clinical practice in the center: Enhancing learning and collaboration in clinical practice through professional development learning community workshops. *Middle School Journal, 48*(4), 3–12. https://doi.org/10.1080/00940771.2017.1343055

Chen, X. (2013). STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001. National Center for Education Statistics, Institute of Education Sciences, U.S. Department of Education.

Clark, D. (2007). Critical Race Feminist Theory. In *Encyclopedia of Law & Society: American and Global Perspectives* (Vol. 1–3, pp. 351–353). Sage Publications, Inc. https://doi.org/10.4135/9781412952637

Collins K. H. (2018). Confronting colorblind STEM talent development: Toward a contextual model for Black student STEM identity. *Journal of Advanced Academics, 9*, 143-168. https://doi.org/10.1177/1932202X18757958

Collins, K. H., & Jones Roberson, J. (2020). Developing STEM Identity and Talent in Underrepresented Students: Lessons Learned From Four Gifted Black Males in a Magnet

School Program. *Gifted Child Today*, *43*(4), 218–230. https://doi.org/10.1177/1076217520940767

Collins, K. H., Joseph, N. M., & Ford, D. Y. (2020). Missing in Action: Gifted Black Girls in Science, Technology, Engineering, and Mathematics. *Gifted Child Today*, *43*(1), 55–63. https://doi.org/10.1177/1076217519880593

Collins, P. H. (2022). *Black feminist thought: Knowledge, consciousness, and the politics of empowerment.* Routledge.

Committee on Equal Opportunities in Science and Engineering. (2000). Biennial report to the United States Congress. Retrieved from http://www.nsf.gov/pubs/2001/ceose2000rpt/congress.pdf

Congressional Research Service. (2022, February 10). S.3636 - strengthening stem ecosystems act - congress.gov. Congress.gov. Retrieved December 28, 2022, from https://www.congress.gov/bill/117th-congress/senate-bill/3636

Cox, M.D. (2006). Phases in the development of a change model: Communities of practice as change agents in higher education. In L. Hunt, A. Bromage, & B. Tomkinson (Eds.), The realities of change in higher education: Interventions to promote learning and teaching (pp. 91-100). New York: Routledge

Crenshaw, K. W. (2017). *On Intersectionality: Essential Writings*. Faculty Books. 255.

Creswell, J. W., & Guetterman, T. C. (2018). *Educational research: Planning, conducting and evaluating quantitative and qualitative research*. Pearson.

Crisp, G., Nora, A., & Taggart, A. (2009). Student Characteristics, Pre-College, College, and Environmental Factors as Predictors of Majoring in and Earning a STEM Degree: An Analysis of Students Attending a Hispanic Serving Institution. *American Educational Research Journal*, *46*(4), 924–942. https://doi.org/10.3102/0002831209349460

Cross, T. L. (1989). Toward a culturally competent system of care. Washington, DC: Georgetown University Child Development Program, Child and Adolescent Service System Program.

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. Learning Policy Institute https://learningpolicyinstitute.org/sites/default/files/product-files/Effective_Teacher_Professional_Development_REPORT.pdf

Delgado, R., & Stefancic, J. (2017). Critical race theory: An Introduction. New York University Press.

Dixon-Payne, D. (2022). In and Out: A Case Study Examining Adolescent Black Girls' STEM Engagement and STEM Identity in Informal STEM Education Programs. UNC Charlotte

Electronic Theses And Dissertations. https://ninercommons.charlotte.edu/islandora/object/etd%3A2647/

DuFour, R. (2004). What is a "professional learning community"? Educational Leadership, 61(8), 6-11.

DuFour, R., DuFour, R., Eaker, R., Many, T., & Mattos, M. (2016). *Learning by Doing: A Handbook for Professional Learning Communities at Work™*, pp. 2–4.

Eaker, R., DuFour, R. & DuFour, R. (2009). *Getting Started: Reculturing Schools to Become Professional Learning Communities*. Solution Tree Press.

Eib, B. J., & Miller, P. (2006). Faculty development as community building-An approach to professional development that supports communities of practice for online teaching. The International Review of Research in Open and Distance Learning, 7(2). Retrieved from http://www.irrodl.org/index.php/irrodl/article/view/299/639

Escobar, M., & Qazi, M. (2020). BUILDERS: A Project-Based Learning Experience to Foster STEM Interest in Students from Underserved High Schools. Journal of STEM Education: Innovations and Research, 21(3), Article 3. https://www.jstem.org/jstem/index.php/JSTEM/article/view/2468

Evans-Winters, V., & Esposito, J. (2010). Other people's daughters: Critical race feminism and Black girls' education. Educational Foundations, 24(1-2), 11–24.

Farinde, A. A., & Lewis, C. W. (2012). The Underrepresentation of African American Female Students in STEM Fields: Implications for Classroom Teachers. 10.

Fenichel, M. & Schweingruber, H.A. (2010). Surrounded by science: Learning science in informal environments. Board on Science Education, Center for Education, Division of Behavioral and Social Sciences and Education. Washington, D.C. The National Academies Press. https://doi.org/10.17226/12614.

Flores III, P. (2020). Leading Praxis for Equity in California Public Education: A Case Study of Transformative Change at a Latino/a Majority Urban High School (Doctoral dissertation, California State University, Fresno).

Fordham, S. (1993). "Those Loud Black Girls": (Black) Women, Silence, and Gender "Passing" in the Academy. *Anthropology & Education Quarterly*, *24*(1), 3–32.

Fouad, N. A., Chang, W.-H., Wan, M., & Singh, R. (2017). Women's Reasons for Leaving the Engineering Field. Frontiers in Psychology, 8. https://doi.org/10.3389/fpsyg.2017.00875

Fulton, K., & Britton, T. (2011). STEM teachers in professional learning communities: From good teachers to great teaching. National Commission on Teaching and America's Future.

Funk, C., &; Parker, K. (2018, January 9). Racial diversity and discrimination in the U.S. STEM workforce. Pew Research Center's Social & Demographic Trends Project.

https://www.pewresearch.org/social-trends/2018/01/09/blacks-in-stem-jobs-are-especially-concerned-about-diversity-and-discrimination-in-the-workplace/.

Giffi, C., Dollar, B., Rodriguez, M. D., & Nabaum, I. A. (2015). American manufacturing competitiveness and the looming skills gap. National Association of Manufacturing and Deloitte, 19.

Gregory, A., Skiba, R. J., & Noguera, P. A. (2010). The achievement gap and the discipline gap. Educational Researcher, 39(1), 59-68.

Hallinen, J. (2021, June 10). STEM. Encyclopedia Britannica. https://www.britannica.com/topic/STEM-education

Hargreaves, A. (2003). Teaching in the Knowledge Society: Education in the Age of Insecurity. Teachers College Press.

Heimlich, J. E., Morrissey, K., Glass, M. A., Storksdieck, M., Schatz, D., & Hunter, N. (2021). Building an Informal STEM Learning Professional Competency Framework. New Horizons in Adult Education and Human Resource Development, 33(1), 25–36. https://doi.org/10.1002/nha3.20303

Hodge, A., Rech, J., Grandgenett, N., & Johnson, K. G. (2020). Campus STEM Innovation from a Foothold in Mathematics: Lessons Learned from a Place Where it Happened. Journal of STEM Education: Innovations and Research, 21(3), Article 3. https://www.jstem.org/jstem/index.php/JSTEM/article/view/2382

Hord, S. M. (2004). Learning Together, Leading Together: Changing Schools Through Professional Learning Communities. Teachers College Press.

Howard-Hamilton, M. F. (2003). Theoretical frameworks for African American women. New Directions for Student Services, 2003(104), 19–27. https://doi.org/10.1002/ss.104

Ireland, D. T., Freeman, K. E., Winston-Proctor, C. E., DeLaine, K. D., McDonald Lowe, S., & Woodson, K. M. (2018). (Un)Hidden Figures: A Synthesis of Research Examining the Intersectional Experiences of Black Women and Girls in STEM Education. *Review of Research in Education*, *42*(1), 226–254. https://doi.org/10.3102/0091732X18759072

Jeffs, T., & Smith, M. K. (2021). The Education of Informal Educators. Education Sciences, 11(9), 488. https://doi.org/10.3390/educsci11090488

Jiang, B., Annis, K., & Lim, W. (2016). Developing Culturally Responsive First-Year Teachers for Urban Schools. *The Journal of Classroom Interaction*, *51*(1), 18–30. http://www.jstor.org/stable/26174347

Johnson, I. R., Pietri, E. S., Fullilove, F., & Mowrer, S. (2019). Exploring Identity-Safety Cues and Allyship Among Black Women Students in STEM Environments. *Psychology of Women Quarterly*, *43*(2), 131–150. https://doi.org/10.1177/0361684319830926

Joseph, N. M., Hailu, M., & Boston, D. (2017). Black Women's and Girls' Persistence in the P–20 Mathematics Pipeline: Two Decades of Children, Youth, and Adult Education Research. *Review of Research in Education, 41*(1), 203–227. https://doi.org/10.3102/0091732X16689045

Kemmis, S., McTaggart, R., & Nixon, R. (2014). *The Action Research Planner*. Springer.

Kezar, A., Gehrke, S., & Bernstein-Sierra, S. (2017). Designing for Success in STEM Communities of Practice: Philosophy and Personal Interactions. The Review of Higher Education, 40(2), 217–244. https://doi.org/10.1353/rhe.2017.0002

Khalifa, M. A., Gooden, M. A., & Davis, J. E. (2016). Culturally Responsive School Leadership: A Synthesis of the Literature. Review of Educational Research, 86(4), 1272–1311.

Kim, A. Y., Sinatra, G. M., & Seyranian, V. (2018). Developing a STEM Identity Among Young Women: A Social Identity Perspective. *Review of Educational Research*, *88*(4), 589–625. https://doi.org/10.3102/0034654318779957

King, N. S. & Pringle, R. M. (2019). Black Girls Speak STEM: Counterstories of Informal and Formal Learning Experiences. *Middle and Secondary Education Faculty Publications, 144*. https://doi.org/10.1002/tea.21513

Kirst, M. W., & Venezia, A. (2004). From high school to college: improving opportunities for success in postsecondary education. Jossey-Bass.

Kraft, C. L. (1991). What Makes a Successful Black Student on a Predominantly White Campus? *American Educational Research Journal*, *28*(2), 423–443. https://doi.org/10.3102/00028312028002423

Krainara, S., & Chatmaneerungcharoen, S. (2019). Building a Professional Learning Community with Team Endeavors while Creating Elementary-focused STEM-integrated Lesson Plans. Journal of Physics: Conference Series, 1340, 012015. https://doi.org/10.1088/1742-6596/1340/1/012015

Kruse, S., Seashore Louis, K., & Bryk, A. (1994). Building professional community in schools. Issues in Restructuring Schools, (6), 3–6. Madison, WI: Center on Organization and Restructuring of Schools.

Ladson-Billings, G. (2013). Lack of achievement or loss of opportunity. In P.L. Carter & K. G. Welner (Eds.), Closing the opportunity gap: What America must do to give every child an even chance (pp. 11-24). Oxford, NY: Oxford University Press.

Leithwood, K., Harris, A., & Hopkins, D. (2008). Seven Strong Claims about Successful School Leadership. School Leadership & Management, 28, 27–42. https://doi.org/10.1080/13632430701800060

Lindsey, R. B., Nuri-Robins, K., Terrell, R. D., & Lindsey, D. B. (2018). *Cultural proficiency: A manual for school leaders* (4th ed.). Corwin Press.

Malcom, S. M., Hall, P. Q., & Brown, J. W. (1976). The Double Bind: The Price of Being a Minority Woman in Science. Report of a Conference of Minority Women Scientists, Arlie House, Warrenton, Virginia. American Association for the Advancement of Science, 1515 Massachusetts Avenue, N. https://eric.ed.gov/?id=ED130851

Marsh, H. W., Van Zanden, B., Parker, P. D., Guo, J., Conigrave, J., & Seaton, M. (2019). Young Women Face Disadvantage to Enrollment in University STEM Coursework Regardless of Prior Achievement and Attitudes. *American Educational Research Journal*, *56*(5), 1629–1680. https://doi.org/10.3102/0002831218824111

McChesney, K. Y. (2015). Teaching Diversity: The Science You Need to Know to Explain Why Race Is Not Biological. SAGE Open, 5(4), 2158244015611712. https://doi.org/10.1177/2158244015611712

McClafferty Jarsky, K., McDonough, P. M., & Núñez, A.-M. (2009). Establishing a College Culture in Secondary Schools Through P-20 Collaboration: A Case Study. *Journal of Hispanic Higher Education*, *8*(4), 357–373. https://doi.org/10.1177/1538192709347846

McGee, E. O. & Robinson, W. H. (2019). Diversifying Stem: Multidisciplinary perspectives on race and gender. Rutgers University Press.

McGee, E. O. (2016). Devalued Black and Latino Racial Identities: A By-Product of STEM College Culture? *American Educational Research Journal, 53*(6), 1626–1662. https://doi.org/10.3102/0002831216676572

McGee, E. O., & Martin, D. B. (2011). ‘‘You would not believe what I have to go through to prove my intellectual value!’’: Stereotype management among academically successful Black mathematics and engineering students. American Education Research Journal, 48(6), 1347–1389.

McPherson, E. (2014). Informal learning in science, math, and engineering majors for African American female undergraduates. *Global Education Review, 1* (4). 96-113.

Merriam, S., & Tisdell, E. (2016). Qualitative research: A guide to design and implementation (fourth). Jossey-Bass.

Milner, H. R. (2012). Beyond a test score. Journal of Black Studies, 43(6), 693-718.

Morton, C., & Smith-Mutegi, D. (2022). Making “it” matter: Developing African-American girls and young women’s mathematics and science identities through informal STEM learning. *Cultural Studies of Science Education, 17*(1), 39-52.

Morton, T. R. (2022). Critical Race Theory and STEM Education. Oxford Research Encyclopedia of Education. https://doi.org/10.1093/acrefore/9780190264093.013.1614

Museus, S. D. (2013). The culturally engaging campus environments (CECE) model: A new theory of success among racially diverse college student populations. Higher Education:

Handbook of Theory and Research, 189–227. https://doi.org/10.1007/978-94-017-8005-6_5

National Center for Education Statistics. (2023). Table 318.45: Number and percentage distribution of science, technology, engineering, and mathematics (STEM) degrees/certificates conferred by postsecondary institutions, by race/ethnicity, level of degree/certificate, and sex of student: 2012–13 through 2021–22 [Data set]. U.S. Department of Education. Accessed May 26, 2024, https://nces.ed.gov/programs/digest/d23/tables/dt23_318.45.asp?current=yes

National Science Foundation. (2022). *Advancing informal stem learning (AISL)*. https://new.nsf.gov/funding/opportunities/advancing-informal-stem-learning-aisl

National Science Foundation (2019). Women, minorities, and persons with disabilities in science and engineering. Retrieved from https://www.nsf.gov/statistics/women/

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis: Striving to Meet the Trustworthiness Criteria. International Journal of Qualitative Methods, 16(1). https://doi.org/10.1177/1609406917733847

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the Double Bind: A Synthesis of Empirical Research on Undergraduate and Graduate Women of Color in Science, Technology, Engineering, and Mathematics. Harvard Educational Review, 81(2), 172–209. https://doi.org/10.17763/haer.81.2.t022245n7x4752v2

Pinkard, N., Erete, S., Martin, C. K., & McKinney de Royston, M. (2017). Digital Youth Divas: Exploring Narrative-Driven Curriculum to Spark Middle School Girls' Interest in Computational Activities. Journal of the Learning Sciences, 26(3), 477–516. https://doi.org/10.1080/10508406.2017.1307199

Pinkard, N., Martin, C. K., & Erete, S. (2020). Equitable approaches: Opportunities for computational thinking with emphasis on creative production and connections to community. Interactive Learning Environments, 28, 347–361. https://doi.org/10.1080/10494820.2019.1636070

Pollock, M. (2008). *Everyday antiracism: Getting real about race in school*. New Press : Distributed by W.W. Norton & Co.

Pollock, M. (2017). Schooltalk: Rethinking what we say about - and to - students every day. The New Press.

Pollock, M., & Matschiner, A. (2024). "Well, What's Wrong with the Whites?": A Conversation Starter on Raising Expectations for Inservice Professional Development on Race with White Teachers. *Urban Education, 59*(6), 1842-1870. https://doi.org/10.1177/00420859221119109

Ravitch, S. M., & Carl, N. M. (2020). Qualitative research: Bridging the conceptual, theoretical, and methodological (2nd ed.). SAGE Publications, Inc.

Rhoulac Smith, T., Mcgowan, J., Allen, A., II, J., Jr, D., Najee-ullah, M., & Peters, M. (2008). Evaluating the Impact of a Faculty Learning Community on STEM Teaching and Learning. Journal of Negro Education, 77.

Santamaría, L. J., & Jean-Marie, G. (2014). Cross-cultural dimensions of applied, critical, and transformational leadership: Women principals advancing social justice and educational equity. Cambridge Journal of Education, 44(3), 333-360.

Scott, K. A., & White, M. A. (2013). COMPUGIRLS' Standpoint: Culturally Responsive Computing and Its Effect on Girls of Color. Urban Education, 48(5), 657–681. https://doi.org/10.1177/0042085913491219

Singleton, G. E. (2015). *Courageous conversations about race: a field guide for achieving equity in schools*. Corwin, A SAGE Company.

Smithsonian Science Education Center. (2016, March 25). The STEM Imperative. https://ssec.si.edu/stem-imperative.

Spencer, M. B., Noll, E., Stoltzfus, J., & Harpalani, V. (2001). Identity and School Adjustment: Revisiting the "Acting White" Assumption. Educational Psychologist, 36(1), 21–30. https://doi.org/10.1207/S15326985EP3601_3

STEM Funders Network. (2020, July 9). San Diego stem ecosystem. STEM Ecosystems. Retrieved February 2, 2023, from https://stemecosystems.org/ecosystem/san-diego-ecosystem/

Swanson, R. D. (2018). Boundary crossings between professional communities: Designing online collaborative learning opportunities for informal stem educators. ProQuest LLC. Retrieved March 16, 2023, from https://eric.ed.gov/?id=ED585904

The White House, Office of the Press Secretary. (2009, November 23). President Obama launches "educate to innovate" Campaign for excellence in science, technology, engineering & math (STEM) education. National Archives and Records Administration. Retrieved December 19, 2022, from https://obamawhitehouse.archives.gov/the-press-office/president-obama-launches-educate-innovate-campaign-excellence-science-technology-en

Tollefson, K., & Magdaleno, K. R. (2016). Educational leaders and the acknowledgment gap. Journal of School Leadership, 26(2), 223-248.

Townley, A. L. (2020). Leveraging Communities of Practice as Professional Learning Communities in Science, Technology, Engineering, Math (STEM) Education. *Education Sciences, 10*(8), 190. https://doi.org/10.3390/educsci10080190

Tran, L., Werner-Avidon, M., & Newton, L. (2013). Successful Professional Learning for Informal Educators: What Is It and How Do We Get There? Journal of Museum Education, 38, 333–348. https://doi.org/10.1080/10598650.2013.11510785

Wade-Jaimes, K., King, N. S., & Schwartz, R. (2021). “You could like science and not be a science person”: Black girls’ negotiation of space and identity in science. Science Education, 105(5), 855–879. https://doi.org/10.1002/sce.21664

Wade-Jaimes, K., & Schwartz, R. (2018). “I don’t think it’s science:” African American girls and the figured world of school science. Journal of Research in Science Teaching, 56(6), 679–706. https://doi.org/10.1002/tea.21521

Wahlstrom, K. L., Louis, K. S., Leithwood, K., & Anderson, S. E. (2010). Investigating the Links to Improved Student Learning. 36.

Welborn, J. (2019). Increasing equity, access, and inclusion through organizational change: A study of implementation and experiences surrounding a school district’s journey toward culturally proficient educational practice. Educational Leadership Review, 20(1), 167-189.

Wenger, E., McDermott, R., & Snyder, W. (2002) Cultivating communities of practice: A guide to managing knowledge. Cambridge, MA: Harvard Business School Press.

Williams, J. C. (2015). The 5 Biases Pushing Women Out of STEM. https://hbr.org/2015/03/the-5-biases-pushing-women-out-of-stem.

Wing, A. K. (1997). Brief reflections toward a multiplicative theory and praxis of being. In A. K. Wing (Ed.), Critical race feminism: A reader (pp. 27–34). New York, NY: New York University Press.

Wing, A. K. (2003). Critical race feminism: A reader. New York University Press.

Young-Wallace, J., Bradley, T., & Howard, B. (2020). The Inner Workings of a STEM Professional Learning Community for Middle School Black Boys at an HBCU.

Zamudio, M. M., Russell, C., Rios, F. A., & Bridgeman, J. L. (2011). Critical race theory matters. Education and ideology. New York. NY: Routledge.

Appendix A
Meeting 1 Background Questionnaire and Initial Interview Questions

- Name (preferred pseudonym)
- Job Title
- Select your current job role: program educator (teacher), or an organization educational leader (executive director, administrator), or none of the above.
- How many years have you worked in informal education?
- Please describe your participation in creating, or implementing STEM programming.

- Organization Name (preferred pseudonym)
- Select all of the following informal education offerings that you support: before-school, after-school, out-of-school, summer activities, none of the above.
- What are the school grade levels of the students who participate in your organization?

- Have you ever participated in a Professional Learning Community (i.e., the San Diego STEM Ecosystem)? How long did you participate? Describe your experience.

- What would be the ideal design of a Professional Learning Community to support your current students?
    - Who - who helps and who limits collaborative discourse,
    - Where - online/in-person modality,
    - When - frequency of meetings/how often,
    - Learning Approach - project based, results focused, professional development, instructor-led/peer-led training.
    - Learning style - research based or not. Read empirical research, focus groups, reflection questionnaires, or none.

Appendix B
Self-Study Questions

Before Focus Group 1: ● How many Black girls per year or per program do you typically serve? ● What more do you need to learn to create a Professional Learning Community to support Black girls in STEM? ● Are you curious about anything that I can bring in to educate all of the participants?
Before Focus Group 2: ● What affirming language does your organization use to recruit, enroll, or retain Black girls? ● How do you assist Black girls to manage stereotypes and positively co-construct their identities (STEM, racial, gender, and otherwise)? ● How does your organization embed asset building, reflection, and connectedness into its offerings?
Before Focus Group 3: ● What are your organization's goals for collaborating with other organizations? How do you see collaboration benefiting your organization, your partners, and the community? ● What types of organizations or job roles have you or your organization collaborated with? Consider: Culturally responsive educators, Supportive educational leaders, Community stakeholders, etc. ● What was productive about your experience with collaboration? What was the most challenging part of the collaboration?

Appendix C
PLC Readings and Focus Group Discussion Prompts

Topic & Focus Group Discussion Prompts	Pre-Selected Reading Options
Meeting 2: Big ideas about the Underrepresentation of Black Girls in STEM ● What stood out to you as the major cause of underrepresentation? ● What stood out to you as the major impact of that underrepresentation? ● How could you concretely address these issues in your work?	Evans-Winters, V., & Esposito, J. (2010). Other people's daughters: Critical race feminism and Black girls' education. *Educational Foundations, 24*(1-2), 11–24.
	McGee, E. O., & Martin, D. B. (2011). ''You would not believe what I have to go through to prove my intellectual value!'': Stereotype management among academically successful Black mathematics and engineering students. *American Education Research Journal, 48*(6), 1347–1389.
	Scott, K. A., & White, M. A. (2013). COMPUGIRLS' Standpoint: Culturally Responsive Computing and Its Effect on Girls of Color. *Urban Education, 48*(5), 657–681. https://doi.org/10.1177/0042085913491219
	Wade-Jaimes, K., & Schwartz, R. (2019). "I don't think it's science:" African American girls and the figured world of school science. *Journal of Research in Science Teaching, 56*(6), 679–706. https://doi.org/10.1002/tea.21521
Meeting 3: Promising Practices to Empower Black Girls' STEM Identity ● What stood out to you as one way to empower Black girls' STEM identity?	Collins, K. H., Joseph, N. M., & Ford, D. Y. (2020). Missing in Action: Gifted Black Girls in Science, Technology, Engineering, and Mathematics. *Gifted Child Today, 43*(1), 55–63. https://doi.org/10.1177/1076217519880593
	King, N. S. & Pringle, R. M., "Black Girls Speak STEM: Counterstories of Informal and Formal Learning Experiences" (2018). *Middle and Secondary Education Faculty Publications.* 144. https://doi.org/10.1002/tea.21513

• Why do you agree or disagree with that method? • How could you concretely empower Black girls in your work?	Morton, C., Smith-Mutegi, D. (2022) Making "it" matter: developing African-American girls and young women's mathematics and science identities through informal STEM learning. *Cultural Studies of Science Education 17*, 39–52 (2022). https://doi.org/10.1007/s11422-022-10105-8
	Pinkard, N., Martin, C. K., & Erete, S. (2020). Equitable approaches: Opportunities for computational thinking with emphasis on creative production and connections to community. *Interactive Learning Environments*, *28*, 347–361. https://doi.org/10.1080/10494820.2019.1636070
Meeting 4: Designing an Informal STEM Professional Learning Community (PLC) for Black Girls • What stood out to you as the major benefit of a PLC to advance STEM learning for Black girls? • What concerns you about belonging to such a PLC? • How would you design this Informal STEM PLC to really help you learn to better serve Black girls? Consider: What would we learn about, what tools or learning styles would we use, and how often should we meet virtually and/or in person?	Bevan, B., Dillon, J., Hein, G., McDonald, M., Michalchik, V., Root, D., Miller, D., Rudder-Kilkenny, L., Xanthoudaki, M., & Yoon, S. (2010). Making Science Matter: Collaborations Between Informal Science Education Organizations and Schools. (Executive Summary, pp. 44-49, Conclusion)
	Fulton, K., & Britton, T. (2011). STEM teachers in professional learning communities: From good teachers to great teaching. National Commission on Teaching and America's Future.
	Heimlich, J. E., Morrissey, K., Glass, M. A., Storksdieck, M., Schatz, D., & Hunter, N. (2021). Building an Informal STEM Learning Professional Competency Framework. *New Horizons in Adult Education and Human Resource Development, 33*(1), 25–36. https://doi.org/10.1002/nha3.20303
	Townley, A. L. (2020). Leveraging Communities of Practice as Professional Learning Communities in Science, Technology, Engineering, Math (STEM) Education. *Education Sciences, 10*(8), 190. https://doi.org/10.3390/educsci10080190

Appendix D

Focus Group reflection questionnaire prompts

Based on today's focus group, your reading, and your lived experience, answer the following questions:
● Have you implemented anything new in your programming since the last session?
● In what ways will you use the research reflected in this session? What is one example that comes to mind?
● What wonderings do you have? What more do you need to know to make this set of ideas workable in your organization?
● How do the different learning modes (reading, discourse, reflection) help you learn or engage [OR NOT] as you consider implementing some of the ideas reflected in this session in your own informal STEM learning organization? ○ What were the positives of each learning mode (reading, discourse, reflection)? ○ What were the limitations of each learning mode (reading, discourse, reflection)? ○ How did the group dynamic itself benefit or limit your learning? ○ How else would you suggest learning about this issue in order to really improve your work to support Black girls?
● To better understand the depth of your reading, answer the following questions: ○ How far in advance did you read the article? Read within 1 hour before the session, Read within 24 hours before the session, Read within 48 hours before the session, Read more than 48 hours before the session. ○ How much of the article did you read? Read all assigned pages, Read various pages, Read various paragraphs, or Read paragraph headers or sentences, I did not read for this session.

Appendix E
Meeting 5 Final Interview Questions

- Name (preferred pseudonym)

- Describe your experience in this temporary Professional Learning Community?
    - What did you learn? How did you participate? How have you or your program changed? Have you or your organization implemented anything new?
- How could this PLC help you or your organization?

- What is your ideal design of a Professional Learning Community for informal STEM education in San Diego County?
    - Who - who helps and who limits collaborative discourse,
    - Where - online/in-person modality,
    - When - frequency of meetings/how often,
    - Learning Approach - project based, results focused, professional development, instructor-led/peer-led training.
    - Learning style - research based or not. Read empirical research, focus groups, reflection questionnaires, or none.

- What more do you need to know to make a Professional Learning Community workable in your setting?
    - What resources do you need to create and sustain a PLC?
    - What wonderings do you have?

- What more do you need to learn to create a Professional Learning Community to support Black girls in STEM?
    - content knowledge about the educational experiences of Black girls, research on best practices, collaborative projects, wonderings