THE EXPERIENCES OF AFRICAN AMERICAN FEMALE UNDERGRADUATE STEM MAJORS IN THE FRESHMAN CHEMISTRY COURSE AT A PREDOMINANTLY WHITE INSTITUTION

by

NATASHA YVONNE JOHNSON

(Under the Direction of DAVID F. JACKSON AND DEBORAH TIPPINS)

ABSTRACT

The purpose of this study was to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Additionally, this research sought to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution. Black Feminist Thought was used as the theoretical framework. This research investigation consisted of two distinct cases; one conducted during the fall semester and one conducted during the spring semester. Each case consisted of African American female undergraduate students who were enrolled in the same freshman chemistry course at University of Georgia. All students participated in a series of co-generative dialogue sessions and an individual interview. The major themes from case one are: a) isolation; b) relationships with faculty; and c) role of social networks and support systems. The major themes from case two are: a) resistance to a weed out culture; and b) racial experiences and a lack of diversity. The findings have implications for future research.

INDEX WORDS: African American female students, freshman chemistry, predominantly White institutions, STEM, co-generative dialogue, Black feminist thought

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DEDICATION

I would like to thank my family and friends who have continued to encourage, motivate, and inspire me throughout this journey. I will forever be thankful for your unconditional love and support. This dissertation is especially dedicated to the following individuals:

My father, Robert Marshall Hillsman Sr.

One of our very last conversations was about my doctoral program and I promised you that I would finish this degree. After you passed, it was very hard to find the strength and motivation to continue this work. On my worst days, I could sometimes feel your presence. I know that you have continued to watch over and guide me. I hope that you are proud of this work.

My mother, Ruth Yvonne Moss Hillsman

I thank you for the gift of education. You were my very first teacher. You taught me and continue to teach me so many valuable lessons about life. You have been with me each and every step of the way. I could not have done it without you. You always said that you wanted me to finish my degree “before you closed your eyes.” We did it, Mom!

Zaniah, Tosin, Tai, Sonji, and Taj

You were all so very young when I started this process. I thank God for each of you. You continue to motivate me each and every day. I pray that one day you will understand why I worked so hard and what I was trying to accomplish. I hope that each of you will find your calling in this life. I hope this work will inspire you to dream big, follow your passion, and never give up.

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I started this journey almost ten years ago. Three years ago, I considered walking away without my degree. During a chance encounter with a professor on campus, I received some advice that would forever change my outlook on this process. I was reminded that this process was never about me. It was not about how prepared I was, how smart I was, not how hard I worked, not how well I wrote, and not about the quality or importance of my research. I was told that I should stop imposing my own time limits for completing this program. I would not finish this process in my time, but in God's time. I would not finish until I had learned everything I was supposed to learn. I would not finish until I had experienced everything I was supposed to experience. As I prepare to end this journey, I am so thankful for the process. I am thankful for the triumphs and the setbacks. I am thankful for the laughter and the tears. As I prepare to begin my next chapter, it is with an understanding that I will be a better scholar in the field of science education because of the many lessons that I have learned as a doctoral student at the University of Georgia.

I thank God for blessing me with a supportive family. I am especially thankful for my: mother, husband, children, niece, siblings, mother-in-law, aunts, and uncles. I appreciate the many friends who continued to encourage me until the very end.

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CHAPTER 1

INTRODUCTION

Statement of the Problem

According to Jackson (2007), there exists a quiet crisis in the United States. This crisis refers to the United States' inability to produce the scientific and technical talent necessary to maintain our economic advantage and support national security interests. This shortage in STEM talent is being fuel by a number of factors, including an aging workforce, global competition, and stagnant interest in STEM disciplines. Jackson (2007) reported that approximately one quarter of the science and engineering workforce would retire by 2010. The percentage of scientists and engineers between the age of 60 and 69 rose from 54% in 1993 to 63% in 2010 (National Science Board, 2014). While students on temporary visas continue to earn large percentages of graduate degrees in science and engineering, 26% of master's degrees and 33% of doctorates, the number of international students in the United States decreased from 25% in 2000 to 19% in 2010. (National Science Board, 2014). Fewer college students major in STEM disciplines in the United States than in other countries, 33% in comparison to the higher rates in China and Japan, 50% and 60%, respectively (National Science Board, 2014). About 5% of all United States bachelor's degrees were awarded in the field of engineering, compared to 31% in China and 18% throughout Asia (National Science Board, 2014). The inability of the United States to attract young talent, coupled with increasing concerns related to our national security and declining economy, make the retention of STEM undergraduate students a vitally important research area. This chapter will explore the educational, cultural, and social factors that contribute to this shortage of STEM talent.

Retention of STEM Talent

Many research studies have attempted to gain an understanding of why students leave the sciences. In his exploration of the empirical evidence surrounding the increasing rates of attrition in STEM areas, Daempfle (2002) found that commonly held explanations such as language barriers created by international professors and assistants, large class sizes, and poor high school instruction were rarely supported. Strenta, Elliot, Matier, Scott, and Adair (1993) depicted the experience of many students in STEM majors:

> The reasons given for attrition are many (Hewitt & Seymour, 1991; Manis et al., 1989; Tobias, 1990): foundation science courses are said to be dull, slighting interesting conceptual and historical approaches in favor of information giving and problem setting; they are very fast-paced, with large workloads and time investments in labs and homework; the difficulty level is high, and inadequate high school preparation nearly condemns a student to relative failure; classes are large, and the grading, usually based on curves, is severe; competition is aggressive, and basic classes appear to be screening mechanisms to weed out the unready, the unmotivated, or the unable; teachers too often show disinterest in teaching and their preference for research, advising is often perfunctory, and the whole system is impersonal (p. 514).

STEM faculty members have long claimed that attrition rates are due to students who lacked the academic preparation, motivation, or natural aptitude to succeed in STEM majors, but the research does not support this claim. Seymour and Hewitt (1997) found that a similar proportion of switchers and non-switchers had experienced conceptual difficulties and that the mean grade point average between these two groups was not substantially different. According to Seymour (2001), concern has emerged that "the undergraduate experience might be contributing to failure to attract or retain able students, and that patterns of losses might be (unwittingly) engineered rather than reflecting "natural" wastage" (p. 82).

Tobias (1990) in her ground-breaking work *They're not Dumb, They're Different: Stalking the Second Tier*, describes the undergraduate science student experience as follows: "The proverbial look to the left, look to the right, two of your classmates will not be here after . . . may have first surfaced at Harvard Law School, but it certainly operates in introductory science where the first painful shakeout is expected to occur" (p. 10). Seymour and Hewitt (1997) described the same "weed out" process experienced by a Black, male undergraduate engineering student. Attrition rates reflect that approximately 40% of STEM students will ultimately major in another discipline and, alarmingly, this rate is even higher for women and "minority" students (Seymour & Hewitt, 1997).

Black Education: Separate and Unequal

Historically, Blacks have been underrepresented in mathematics and science careers. In 2008, Blacks represented 12 percent of the U.S. population and 11 percent of all undergraduate enrollments, but they earned just 9 percent of STEM bachelor's degrees in 2009 (American Institutes for Research, 2012). In 2010, Blacks received 7 percent of all bachelor's degrees awarded in the biological sciences, 6 percent in the physical sciences, 5 percent in mathematics and statistics, and only 4 percent of the bachelor's degrees awarded in engineering (NSF, 2011). Blacks have been denied access to careers in STEM by a number of historical, educational, and social factors.

Blacks emerged from slavery with a strong belief in the desirability of learning to read and write. "There is one sin that slavery committed against me," professed one ex-slave, "which I will never forgive. It robbed me of my education" (Anderson, 1988). This desire would lead Blacks to pool financial and labor resources to establish universal schools which eventually led to the establishment of public education for all children (Anderson, 1988). Education has long been viewed in American culture as the "great equalizer"; as a pathway to achieve the American dream regardless of race, gender, or social class. For years following the end of the civil war, Black children would continue to be educated in "separate, but equal" facilities legalized by the Plessy vs Ferguson court case. Despite evidence of gross disparities in resources and facilities, this segregated system would remain in place until the landmark Brown vs. the Board of Education decision of 1954. This legislation became the focal point for the popular documentary series *Eyes on the Prize* which highlights key events of the Civil Rights movement from 1954 to 1985. In one segment, parent Ruth Batson explained, "When we fight about education, we are fighting for our lives" (Hampton, 1986). The notion that Black and White children deserve the same educational opportunities was a central theme to the desegregation movement. Building on this theme, Gloria Ladson Billings (2000) discussed how historically public education and teachers have not been properly trained to meet the needs of Black students. Even following forced integration, this pattern of segregation has persisted. Black students are more segregated today than they were during the Civil Rights movement. According to the National Center for Education Statistics (2012), approximately 74% of Black students attend schools that are 50 to 100% minority, 40% of Black students attend schools that are 90 to 100% minority, and 15% of Black students attends schools that are 99 to 100% minority. Even in more integrated school settings, Black students will often experience within school segregation as a result of being “disproportionately placed in low-ability level tracks and special education classes” (Irvine, 2003, p. 3).

Structural inequalities influence the science learning of Black and underrepresented populations in rural and urban classrooms in the United States. It is difficult to discuss the challenges of underrepresented groups without a discussion of social class, as the two topics are so closely linked. Black and other marginalized groups experience higher rates of poverty and tend to have lower academic achievement due to differences in educational opportunities and experiences (Tobin, Seiler, & Walls, 1999).

Yerrick, Schiller, and Reisfeld (2010) discussed the trials of rural lower track science classes, such as “more challenging larger class sizes, a wider range of educational special needs, fewer resources, and typically the least prepared teachers for the task of bringing historically failing students to success” (p. 15). These inexperienced teachers faced challenges that would be daunting for even the most talented and seasoned teachers. According to Atwater (2000), urban schools are often more poorly equipped than suburban schools. It is not uncommon to find science classrooms lacking the proper lab equipment, textbooks, and now in more recent years, access to instructional technology (Atwater, 2000). This absence of physical and human resources to support science instruction and supplementary activities, such as science fair projects and science clubs, often creates a greater financial need in urban and rural schools.

Even though Black students tend to gravitate towards careers in the social sciences and education, there are still only a small percentage of Blacks employed as science teachers in the United States. In 2000, although Blacks comprised 12% of the United States population roughly 90% of high school science teachers were White and around 4% were Black. In 2011, approximately 84.5% of high school science teachers were White and approximately 5.4% were

Black (National Center for Education Statistics, 2012). As a result, Black students are routinely denied access to same race role models in the sciences in the years leading up to their declaration of a college major. Once on campus, this pattern of lack of representation persists within STEM departments with Blacks representing only 4.9% of all full-time faculty at four-year institutions in engineering and 3.4% in natural sciences (Cataldi et al, 2005). As we continue to search for answers to the greatest science and technological questions of the 21st century, African Americans remain an "untapped talent" with "unlimited potential" to offer innovative solutions to these most important problems (Russell & Atwater, 2005).

HBCUs Role in the Development of Black STEM Talent

The late United States Supreme Court Justice Antonin Scalia created a firestorm of controversy when he stated, "Most of the Black scientists in this country don't come from schools like the University of Texas. They come from lesser schools" (Carroll & Gillin, 2015). This claim was supported by citing a research study that showed 40 percent of Black students graduating with science and engineering degrees come from historically Black colleges and universities (HBCUs), where students typically have lower average SAT scores and high school grades (Strenta, Elliott, Matier, Scott, & Adair, 1993). Most would question his use of the term "lesser" to describe any institution of higher learning as opposed to more factual descriptors, but his statement highlights the significant contribution of HBCUs in increasing the number of Black students who pursue and attain degrees in STEM fields.

While HBCUs make up less than three percent of U.S. postsecondary institutions, they demonstrate considerable success in awarding degrees to Black students. In 2010, HBCUs contributed 19.2 percent of the 8.6 percent of bachelor's degrees in science and engineering awarded to Blacks. HBCUs awarded 32.5 percent of the bachelor degrees in mathematics and statistics awarded to Blacks in 2010 and 36.6 percent in the physical sciences (Guzman & Nyugen, 2014). While there has been moderate, national improvement in STEM graduation among Black students, HBCUs continue to play a prevalent role in increasing the number of "minorities" in the sciences (Guzman & Nyugen, 2014). The percentage of Black students who attend HBCUs has steadily declined from 90% in 1960 to 8% today (Carroll & Gillin, 2015). Females continue to earn more degrees than males within each racial/ethnic group and Black females receive more than twice as many as Black males (Carroll & Gillin, 2015). Research indicates that Black students attending predominantly White institutions are less likely to graduate with STEM degrees. Faculty and administration at predominately White institutions (PWIs) will need to take action to address the changing demographics on campus and meet the needs of more diverse student populations.

So why do HBCUs experience such success? According to Guzman & Nyugen (2014), traditional approaches to teaching and learning that emphasize competition and individual performance may actually inhibit the performance of Black students. The science education community at large can look to HBCUs' unconventional approaches that emphasize communal success, experiential learning, and targeted support for a potentially transformative model to promote greater success in STEM fields among Black students and other "at-risk" populations.

Freshman Chemistry as a Gatekeeper

Astin and Astin (1993) found that the greatest losses of students changing from STEM to non-STEM majors occur at or before enrollment in college. After students begin their undergraduate experience, they are most likely to transition to a non-STEM major at the end of their first year. Many students decide to pursue non-STEM majors at the end of their freshman year when they are not able to perform well enough to ensure their competitiveness and acceptance into professional programs. According to House (1996), student achievement in introductory college science courses is important because a large number of career options in the basic sciences, engineering, and health sciences require satisfactory grades to enroll in more advanced courses. Hilton and Lee (1988) reported that as student time in college increases, the risk of attrition declines. It is for this reason that we must ensure that students experience success in their introductory science coursework, typically the freshman chemistry course.

According to Tai, Sadler, and Loehr (2005), chemistry is viewed as the central science, as mastery of its concepts is essential to further coursework in all of the sciences. Evidence for this belief lies in the order of coursework required at many major universities in the United States. (p.988). In this way, introductory chemistry serves as a gatekeeper to many careers in the sciences, which provides a rationale for understanding the key factors that contribute to success, failure, and academic experiences in introductory college chemistry. Although a gap exists in the literature, previous research indicates that factors contributing to success in college chemistry can be classified as demographic background, general education background, and previous science learning experiences (Tai, Sadler, & Loehr, 1995).

While some factors are more easily controlled than others, they offer tremendous insight into why some students find a greater degree of success during the freshman chemistry experience. Research indicates that the factors previously discussed account for the learning difficulties of all chemistry students, however additional factors create barriers to science achievement for Black students. Black students' ability to learn science is influenced by additional factors such as: (a) learning styles and multiple intelligences; (b) tracking and ability grouping; (c) structural inequalities; and (d) psychological factors. Black female students are further impacted for reasons related to gender differences: a) experiences in the classroom; b) perceptions of scientists and science careers; and c) interests and attitudes towards studying science.

Black Feminist Theoretical Framework

Black feminism as a political/social movement grew out of Black women's feelings of disgruntlement with both the Civil Rights movement and the White feminist movement of the 1960s and 1970s, respectively. Black feminist thought advances a fundamental paradigmatic shift in how researchers think about oppression (Collins, 2005). By embracing a paradigm of race, class, and gender as interlocking systems of oppression, Black feminist thought reconceptualizes the social relations of dominance and resistance. Second, Black feminist thought addresses the ongoing epistemological debates in feminist theory and sociology of knowledge concerning ways of accessing "truth." Offering Black females new knowledge about their own experiences can be empowering, but revealing new ways of knowing that allow Black females to define their own reality has far greater consequences (Hooks, 1981). Consequently, Black feminist thought is an appropriate paradigm for this study of Black, female undergraduate STEM students' voices as they offer insight into their experience in the freshman chemistry course at a predominantly White institution.

Black feminist thought strives to develop "facts and theories about the Black female experience that will clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16). According to Collins (2002), there are three major principles that define Black Feminist Thought that serves as the theoretical perspective for this research investigation. First, the theoretical framework has evolved out of the experiences Black women have encountered during their lives. Second, despite unique stories and experiences common themes emerge regarding the experiences of all of these women. Third, the rich differences in class, age, geographical locations, and sexual orientations offer a greater context allowing researchers to truly make meaning behind the experiences of Black women. Historically, Black women have been both marginalized and oppressed in many social and academic settings as a result of their race and gender. Howard-Hamilton (2003) describes this marginalization as the "outsider within" status. For many Black females, their placement in courses at PWIs creates a certain level of duality. On the surface, they possess the same credentials and qualifications as the dominant group, but their voice is often silenced by cultural and personal differences.

Significance of the Study

According to Malcom, Hall, and Brown (1976), Black women in the sciences have historically faced challenges associated with both race and gender, creating what has been referred to as a "double bind". Programs designed to meet the needs of minorities or women, often fall short in meeting the needs of this unique population. Despite the progress of the past thirty five years, disparities remain in degree attainment across many science, technology, engineering and math (STEM) disciplines. Additional research is needed to examine the individual and institutional factors that create obstacles to "minority" women choosing and succeeding in STEM fields (Malcom & Malcom, 2011, p. 165). The increasing numbers of Black female students in undergraduate STEM programs at PWIs coupled with the importance of mastery in the freshman chemistry course to future science study, makes this an important area of research, particularly for STEM programs hoping to attract and retain these individuals.

Using a Black feminist theoretical framework, this research seeks to utilize co-generative dialogue sessions among Black females to allow these participants to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Co-generative dialogue or cogen "offers teachers and their students a methodological and theoretical framework for engaging in meaningful research in their own classrooms (Martin, 2006, p. 695). Co-generative dialogues are a form of structured discourse that allow all stakeholders to work collaboratively to improve the quality of teaching and learning in an academic setting (Martin, 2006). The term "cogen" evolved out of the intended outcome of this activity. The "co" means together and "gen" comes from the word generate (Tobin, 2014). Cogen consist of two or more individuals having a structured conversation about a shared event or experience (LaVan, 2004). Co-generative dialogues when properly implemented can benefit students and teachers for many reasons. It can shift the power differential in the science classroom by empowering students to share the responsibility for making and sustaining change. Cogen initiates student contributions that are both valuable and valid, leading to a productive means of improving learning experiences. Additionally, when dialogue occurs across achievement borders it allows students an opportunity to "recognize that individual student experiences with and in science (and school) differ from one to another" (Martin, 2006, p. 716).

The purpose of this study is to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Additionally, this research seeks to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution.

Specifically, this research will address the following questions:

1. What issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly

White institution?

2. What “stories” emerge from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution?
3. What possible solutions are cogenerated by African American female undergraduate STEM students during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution?

Definition of Terms

1. ***Black or African American*** refers to persons of African descent who were born, raised, and live in the United States of America.
2. ***Historically Black Colleges and Universities (HBCU)*** refers to the over 100 institutions (including public and private institutions, community and four-year institutions) of higher education in the United States that were established before 1964 with the intention of primarily serving the African American community.
3. ***Predominately White Institution (PWI)*** refers to institutions of higher learning in which Whites account for 50% or greater of the student enrollment.
4. ***STEM*** is defined as an academic major in science, technology, engineering or mathematics leading to a STEM career, advanced degree and/or entry into the professional fields of pharmacy, dentistry, medicine, nursing, or veterinary medicine.

Chapter Summary

Despite the rhetoric and emphasis placed on STEM education, over the past 50 years very little change has occurred in the areas of student interest and student performance in these fields. Although more students are pursuing post-secondary options than at any other time in the nation's history, student interest and enrollment in STEM majors has remained flat (National Science Board, 2014). Much of the current research has focused on improving the quality of science instruction at the K-12 level, recruitment of highly qualified teachers in critical need areas, and retention of undergraduate STEM students, especially women and underrepresented "minorities." This research investigation shifts the focus to the freshman chemistry experience, to not only identify critical issues, but to find solutions to improve the quality of teaching and learning for students. "The teaching of science has continued to cater to a small number of students who excel in it and choose to make science as career while ignoring the needs of a larger population who do not excel in science and feel excluded from it" (Martin, 2006, p. 694). Research indicates that programs designed to meet the needs of "minorities" or women, often fall short in meeting the needs of Black females, so this study focuses on this unique population. Using a Black feminist lens, this investigation will illuminate the experiences of Black females in freshman chemistry at a predominantly White institution with the ultimate goal of providing recommendations to the chemistry faculty on the most effective instructional strategies and interventions to meet the needs of Black females.

CHAPTER 2

LITERATURE REVIEW

The first part of this chapter will introduce the theoretical framework that has been chosen for this study: Black Feminist Thought. The second part of this chapter explores relevant literature surrounding the following questions: What factors influence the learning of chemistry? What additional factors influence the learning of science for African American and female students? This part of the chapter highlights some reasons from the current literature for why students might experience academic difficulty in the freshman chemistry sequence.

Theoretical Framework of Study

Black Feminist Theory

"We have to see clearly that we are a unique group, set undeniably apart because of race and sex, with a unique set of challenges" (Cleage, 1993, p. 55).

Black feminism as a political/social movement grew out of Black women's feelings of disgruntlement with both the Civil Rights movement and the White feminist movement of the 1960s and 1970s, respectively. Black feminist thought advances a fundamental paradigmatic shift in how researchers think about oppression (Collins, 2005). By embracing a paradigm of race, class, and gender as interlocking systems of oppression, Black feminist thought reconceptualizes the social relations of dominance and resistance. Second, Black feminist thought addresses the ongoing epistemological debates in feminist theory and sociology of knowledge concerning ways of accessing "truth." Offering Black females new knowledge about their own experiences can be empowering, but revealing new ways of knowing that allow Black females to define their own reality has far greater consequences (Hooks, 1981). Consequently, Black feminist thought is an appropriate paradigm for this study of Black, female undergraduate STEM students' voices as they offer insight into their experience in the freshman chemistry course at a predominantly White institution.

Black feminist thought strives to develop "facts and theories about the Black female experience that will clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16). According to Collins (2002), there are three major assumptions that define Black Feminist Thought that serves as the theoretical perspective for this research investigation. First, the theoretical framework has evolved out of the experiences Black women have encountered during their lives. Second, despite unique stories and experiences common themes emerge regarding the experiences of all of these women. Third, the rich differences in class, age, geographical locations, and sexual orientations offer a greater context allowing researchers to truly make meaning behind the experiences of Black women.

Historically, Black women have been both marginalized and oppressed in many social and academic settings as a results of their race and gender. Howard-Hamilton (2003) describes this marginalization as the "outsider within" status. For many Black females, their placement in courses at PWIs creates a certain level of duality. On the surface, they possess the same credentials and qualifications as the dominant group, but their voice is often silenced by cultural and personal differences. Black feminist scholars have developed the following three themes to guide research and inquiry: a) Black women's self-definition and self-valuation; b) interlocking nature of oppression; and c) importance of Black women's culture.

Black women's self-definition and self-valuation

The importance of Black women's self-definition and self-valuation is a central theme to Black Feminist thought. Self-definition involves "challenging the political knowledge-validation process that has resulted in externally-defined, stereotypical images" of what it means to be a Black woman and self-valuation "stresses the content of Black women's self-definitions," that is the need to replace these images with "authentic Black female images" (Collins, 1986, p. 16). The absence of Black female representation in chemistry and in broader STEM fields at predominantly White institutions can make this process "necessary for Black female survival" (Collins, 1986, p. 19). It is not uncommon to experience feelings of isolation or invisibility as the only or as one of very few Black females in this academic setting. Additionally, the lack of representation in the faculty, teaching, and support staff can create additional challenges to the ability of Black females to align career aspirations with "similar" role models. The internalization of stereotypes can negatively impact the self-esteem of even the most prepared Black females (Collins, 1986). Self-definition and self-valuation offers a form of resistance to "the status of being the "other" and implications of being "other than" or different from the assumed norm of white and/or male behavior" (Collins, 1986, p. 18).

The Interlocking Nature of Oppression

Another important theme to Black Feminist thought is the interlocking nature of oppression. This perspective "shifts the entire focus of investigation from one aimed at explicating elements of race or gender or class oppression to one whose goal is to determine what the links are among these systems" (Collins, 1986, p. 20). This more traditional approach has proven to be problematic in that it "prioritizes one form of oppression as being primary, then handles remaining types of oppression as variables within what is seen as the most important system" (Collins, 1986, p. 20). This analysis is important for this investigation given the academic challenges experienced by African American females in the freshman chemistry course. It is noteworthy that this population has the greatest challenges in the course when one considers the low percentage of students who earn A's or B's coupled with the high percentage of students who earn C's, D's, F's or who simply withdraw from the course prior to completion. There is a great deal of academic support available for the freshman chemistry course, but research indicates that often times programs designed to meet the needs of minorities or women, often fall short in meeting the needs of African American females. One of the goals of this researcher and Black feminists is to "develop new theoretical interpretations of the interaction itself" and not to "add to existing theories by inserting previously excluded variables" (Collins, 1986, p. 20). Although this investigation is focused on Black females, experiences in the freshman chemistry course are certainly not isolated to Black female students. Black feminist thought recognizes that researchers "who see the simultaneity of oppression affecting Black women appear to be more sensitive to how these same oppressive systems affect Black men, people of color, women, and the dominant group itself (Collins, 1986, p. 21).

Importance of Black Women's Culture

Another essential theme to Black feminist thought is the desire to "redefine and explain the importance of Black women's culture" (Collins, 1986, p. 21). Black women's culture serves as a "concrete, material expression" of the "symbols and values of self-definition and self-valuation" to cope with the oppression experienced in daily life (Collins, 1986, p. 21). Exploration of Black women's culture has focused our attention to other factors that influence the Black female experience. Factors including the "sisterhood" or relationships shared between Black women, the role of matriarch held by Black women to not just biological children, but to children in their extended family and other children in their communities, and the role of creative expression (Collins, 1986). Black women's culture is viewed as a survival mechanism for a number of reasons. This cultural expression represents a way that "Black women may overtly conform to the societal roles laid out for them, yet covertly oppose these roles in numerous spheres" (Collins, 1986, p. 22). It may also represent a form of "activism" in environments where traditional forms of activism are impossible (Collins, 1986). Black women's culture serves as a model to investigate the relationship between oppression, consciousness, and activism. The most important consequence of this model for this current investigation is the notion that "Black-female spheres of influence may, in turn, affect their perceptions of the political and economic choices offered to them by oppressive structures, influence actions actually taken, and ultimately, alter the nature of oppression they experience" (Collins, 1986, p. 24). Participation in these dialogue sessions with other Black females may serve as a "Black-female sphere of influence" where the students can cogenerate and "validate what will be appropriate, Black-female sanctioned responses to oppression" (Collins, 1986, p. 24).

A Review of Relevant Literature: Factors That Influence Chemistry Learning

According to Sirhan (2007), "chemistry is one of the most important branches of science" because it lays the foundation for very abstract concepts that are used in future chemistry and science coursework (p.2). In addition to the abstract nature of concepts such as the mole and atomic structure, advanced topics such as stoichiometry and kinetics require the ability to solve mathematical problems. The most common areas of difficulty for students studying chemistry are: (a) curriculum content; (b) overload of students' working memory space; (c) language and communication; (d) concept formation (e) motivation (Sirhan, 2007); and (f) high school science experiences.

Curriculum Content

Chemistry is the study of matter and the various physical and chemical changes that occur in that matter (Whitten, Gailey & Davis, 1988). Many students have struggled to make sense of the more abstract and mathematical concepts associated with this subject. Chemistry curriculum spans three levels from the microscopic to the macroscopic to the symbolic level. At the microscopic level, students must learn to conceptualize the relative size and behavior of subatomic particles, atoms, and molecules (Sirhan, 2007). At the macroscopic level, students often perform hands on laboratory investigations to observe various scientific phenomena. Additionally, students are often required to work problems that represent these chemical interactions using symbolic representations. How many students are truly able to grasp that when you mix sugar and sulfuric acid these substances are equivalent to large quantities of microscopic particles consisting of carbon, hydrogen, oxygen, and sulfur? Students often fail to make connections between the three levels, which leads to a superficial understanding of the content (Sirhan, 2007). Subsequently, students are often able to demonstrate knowledge when presented with problems containing numbers and symbols, but struggle to make sense of particle representations for similar concepts (Sawrey, 1990).

Overload of students' working memory space

Memory is the power or process of reproducing or recalling what has been learned and retained especially through associative mechanisms. According to Sirhan (2007), working memory space refers to the human capacity to organize and make sense of large amounts of complex information that is being presented to the chemistry learner. While some students have a tendency to become overwhelmed, more successful students will be able to draw on previous knowledge and relate it to new information, a process called “chunking” (Sawrey, 1990).

Constructivism is a theory of knowledge that argues that humans generate knowledge and meaning from an interaction between their experiences and their ideas. Another postulate of the constructivist view of learning discussed by Limon (2001) is the "importance of connecting the new knowledge to be acquired with the existing knowledge that students have, in order to promote meaningful learning" (p. 358). When chemistry students are introduced to the mole concept, some students are intimidated by the use of Avogadro's number and advanced mathematics topics. For the student who can relate this topic to the familiar mathematics concepts such as exponents, and unit conversions, mastery of the mole concept becomes a less daunting task.

Language and communication

Language and communication create an additional barrier for students learning chemistry. Research indicates that knowledge of words, ability to access that knowledge efficiently, and ability to integrate new concepts into existing conceptual schemata are key factors in reading and listening comprehension, especially at levels of schooling beyond the middle grades (Hennings, 2000). People with limited vocabularies have trouble understanding what they read and hear because they have "too few building blocks" with which to construct meanings (Hennings, 2000). Students are also likely to encounter words that have a different scientific meaning than the everyday use of the word (Cassels & Johnstone, 1985). Vocabulary knowledge is fundamental to reading comprehension; one cannot understand text without knowing what most of the words mean (Knezovich, Tierney & Wright, 1999). Many students are not able to make sense of the multitude of complex and unfamiliar vocabulary words they encounter during the study of chemistry.

Concept formation

As a high school science teacher, students' misconceptions are a common obstacle to learning and understanding new content. The term "misconception" refers to a science conception that differs from currently accepted scientific knowledge (Burgoon, Heddle, & Duran, 2010). One common misconception observed in the chemistry classroom is the belief that air does not consist of matter. By definition, matter is defined as anything that has mass and takes up space. Students often struggle to make sense of how air applies to either part of this definition. This is a logical conclusion when one considers the relatively small mass associated with air and the absence of color and odor. Although students have witnessed air being used to fill up items such as balloons and plastic bags, students struggle to accept this new explanation. Assessments typically reveal that students continue to doubt the classification of air as matter. According to Watson and Konicek (1990), "students tend to cling to their own conceptions even after experiencing events that directly challenge those conceptions," therefore dissatisfaction alone will not cause students to reconstruct conceptual frameworks (Burgoon et al., 2010). When students come to school with such strong preconceived notions regarding scientific phenomenon, the identification and correction of student misconceptions can be a formidable task for even the most talented instructors.

Motivation

According to Sirhan (2007), motivation is a key factor to determining the success of learning for a chemistry student. Motivation is defined as the process that initiates, guides and maintains goal-oriented behaviors (Cherry, n.d.). Zusho, Pintrick, & Coppola (2003) discuss the four components to motivational processes: a) self-efficacy; b) students' beliefs; c) goal orientation; and d) affect. Self-efficacy refers to a student's confidence in their ability to perform a specific task. Research indicates that students' who display the greatest degree of self-efficacy also display the highest academic achievement and academic behaviors. Students' beliefs refer to how useful and applicable the course content is to the current and future goals. Similar to self-efficacy, when students value a specific task it results in greater cognitive processing and performance (Zusho, Pintrich, & Coppola, 2003). Goal orientation refers to the two primary achievement goals of students, mastery and performance. Students who are focused on mastery of content perform better than students who focus on academic grades or competition among peers (Zusho, Pintrich, & Coppola, 2003). Affect is the extent to which a student finds interest or enjoyment in the study of a particular topic. When students are personally interested in a subject matter, it results in deeper cognitive processing and higher academic performance. In contrast, when students are anxious or associate more negative emotions with a content area, the result is a more superficial cognitive processing and academic performance (Zusho, Pintrich, & Coppola 2003; Sirhan, 2007).

High school science experiences

As educators and researchers, the factor that we may have the most control over is the quality of high school science experiences. In a research study, over 60 high school science teachers were observed and researchers found that teacher knowledge, beliefs, and experiences had a great deal of influence on choices regarding instructional strategies (Weiss, Pasley, Smith, Banilower, & Heck, 2003). Another research study examined the relationship between high school chemistry pedagogical experiences and performance in introductory college chemistry while accounting for individual educational and demographic differences (Tai, Sadler, & Loehr, 1995). Students were found to be at a greater advantage in college chemistry based on course structure, laboratory experiences and type of assessments.

Students who had high school chemistry courses that emphasized depth over breadth performed better than their counterparts, so instructional strategies that emphasize deep understanding are more helpful than emphasis on memorization. Another key finding was the importance of high school programs that provided a strong foundation in stoichiometry. Stoichiometry is a mathematical concept that explores the relationship between reactants and products in a balanced chemical equation. This topic is very important to student success in more advanced chemistry concepts, requiring an understanding of basic chemical principles and critical thinking skills.

In recent years, there has been a push for more student access to inquiry activities and hands-on laboratory experiences. This research suggests that the quality of these laboratories may be more important than the quantity (Tai, Sadler, & Loehr, 1995). As physicist Samuel Devons of Barnard College reflected:

> . . .experiment is a craft. . .craft is knowledge you have in your fingertips, little tricks you learn from doing things, and when they don't work and you do them again. You have little setbacks and you think, how can I overcome them? And then you find a way. (Crease, 2003, p. 184–185)

Students reporting more instances of repeating laboratories to enhance their understanding earned higher college chemistry grades than their peers who reported few or no instances of repeating labs for understanding (Tai, Sadler, & Loehr, 1995, p. 1004). Students who understand the importance of learning chemical concepts will approach future learning opportunities with a different perspective than students who are focused primarily on the completion of assignments.

Other than instructional approach and laboratory experience, assessments were found to be a key difference in the overall quality of high school learning experience. According to Tai, Sadler, & Loehr (1995), students reporting greater frequency of test questions requiring memorization and class assignments with problems requiring calculations earned higher college chemistry grades (p. 1005). While teachers should not emphasize recitation of factual information, students who have a greater recall of basic information and facts will be better equipped to manage and navigate in formal assessments. Additionally assessments that stress problem-solving skills are beneficial, perhaps not solely because they reinforce key skills, but they also mimic the freshman chemistry experience.

Factors That Influence Science Learning of African American Students

While research indicates that the factors previously discussed account for the learning difficulties of all chemistry students, it is my contention that additional factors create barriers to science achievement for African American students. African American students' ability to learn science is influenced by four additional factors: a) learning styles and multiple intelligences; b) tracking and ability grouping; c) structural inequalities; and d) psychological factors.

Learning Styles and Multiple Intelligences

Intelligence is the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria. Historically, intelligence tests such as the Stanford-Binet have measured the ability of an individual to perform specific tasks with no consideration of that person's strengths or weaknesses. In 1983, Howard Gardner introduced his theory of multiple intelligences and proposed that intelligence consists of seven different capacities including linguistic, musical, logical-mathematical, spatial, bodily-kinesthetic, interpersonal, and intrapersonal (Dickinson, 1996). It was his belief that these intelligences existed along a continuum and that no two individuals would be exactly alike in their ability to approach problems and create products (Dickinson, 1996).

Unfortunately, as discussed by Dickinson (1996) most schools focus primarily on verbal/linguistic and logical/mathematical abilities, which fail to give many children an opportunity to learn through their strengths and ultimately reach their full potential. This is certainly evident in the science classroom and the chemistry lecture hall. Mackeracher (2004) contends that "what one values and believes to be true about learning is incorporated into one's philosophical orientation to learning and to learners, and determines how one is likely to facilitate learning" (p. 5). As a result, most educators tend to favor their own learning styles and teach the way they were taught in most K-12 and college classes. This cycle perpetuates our dependence on verbal and mathematical abilities. The consequences have an enormous impact on the quality of teaching and learning for many students as discussed in the following quote:

> Most people (at least in western cultures) and presumably most students in science classes are visual learners [2] while the information presented in almost every lecture course is overwhelmingly verbal---written words and formulas in texts and on the chalkboard, spoken words in lectures, with only an occasional diagram, chart, or demonstration breaking the pattern. Professors should not be surprised when many of their students cannot reproduce information that was presented to them not long before; it may have been expressed but it was never heard (p. 3).

According to Felder (1993), "Students whose learning styles are compatible with the teaching style of a course instructor tend to retain information longer, apply it more effectively, and have more positive post-course attitudes toward the subject than do their counterparts who experience learning/teaching style mismatches (p.1). Cafferty (1981) reports that the greater the match between the students' and the teachers' style, the higher the grade point average. Likewise, the greater the mismatch between the students and teachers' style, the lower the grade point average. Research suggests that African American children learn best through visual methods, through kinesthetic and tactile strategies, and using communal learning strategies (Atwater, Atkinson, Woodard, & Johnson, 2013; Boykin, Tyler, & Miller, 2005; Watkins, 2002). Science professors are ill equipped to meet the academic and instructional needs of such students because they lack the pedagogical training and instructional strategies. African American students are likely to continue to experience academic difficulty in the area of science until educators learn to deliver instruction in a manner that addresses their unique talents and learning needs.

Tracking of Students

According to Slavin (1990), tracking or ability grouping has been one of the most controversial issues in education for more than 70 years. Tracking refers to the practice of sorting students into classes or tracks based on academic ability (Gilbert & Yerrick, 2000). In most public school systems, these academic tracks consist of college preparatory, general education, and vocational coursework (Carbonaro, 2005). On the surface, tracking appears to be an efficient means of meeting the needs of a diverse group of learners. Unfortunately, this practice serves to determine the amount, quality, and value of the education received by students in the same school and ultimately leads to a reproduction of the social class hierarchy that exists in the United States (Gilbert & Yerrick, 2000). According to Brantlinger (2003), as discussed in the following passage, inequities in "minority" education exist throughout the educational experience:

> When I observe at Head Start, I am bothered that their curriculum is not as academically or intellectually oriented as private preschools. Distinctive program orientations and expectations for pupils surely figure into the differential readiness status of their respective pupils when they go on to kindergarten. I am also troubled to see the skills orientation and pedantic pedagogy of some low-income schools contrasts with the enriched and interesting curriculum and respectful pedagogy of those affluent neighborhoods. (p. 84)

As a result "unequal educational opportunities for tracked students sets up educational trajectories leading to different levels of educational and occupational attainment with lifelong consequences stemming from a systemic problem beginning quite early in lower track students' educational careers" (Gilbert & Yerrick, 2000, p. 575). In most public schools, African Americans and other marginalized populations are overrepresented while White students are underrepresented in lower tracks (Gilbert & Yerrick, 2000).

Enrollment in these lower ability groups has dire consequences for African American students. Research investigations indicate that higher ability groups experience a higher quality of instruction and additional instructional time which results in greater curricular coverage (Carbonaro, 2005). Lower track courses are characterized by increased discipline, increased structure and a dilution of the content (Yerrick, 2000). Lower track students are more likely to perform poorly on standardized tests, read below grade level, and exhibit "oppositional" behaviors (Yerrick, Schiller, & Reisfeld, 2010). Best practices such as inquiry and classroom discussions are rare, replaced with instructional approaches that limit student input and control the learning experiences. As a result, "lower track students become convinced that not all students can succeed in higher level science and that science is best represented by disseminated facts, watered-down content, and the practice of basic process skills in the absence of meaningful contexts" (Yerrick, 2000, p. 809). According to Yerrick (2000), "these approaches can serve to severely limit or stifle a teacher's ability to promote the kind of scientific literacy argued for in many current reforms" and it fails to develop the critical thinking and problem solving skills necessary to compete in a global society (p. 809).

Structural Inequalities

Structural inequalities influence the science learning of African American and underrepresented populations in rural and urban classrooms in the United States. It is difficult to discuss the challenges of underrepresented groups without a discussion of social class, as the two topics are so closely linked. African Americans and other marginalized groups experience higher rates of poverty and tend to have lower academic achievement due to differences in educational opportunities and experiences (Tobin, Seiler, & Walls, 1999).

Yerrick, Schiller, and Reisfeld (2010) discuss the trials of rural lower track science classes, such as "more challenging larger class sizes, a wider range of educational special needs, fewer resources, and typically the least prepared teachers for the task of bringing historically failing students to success" (p. 15). These inexperienced teachers face challenges that would be daunting for even the most talented and seasoned teachers. In the following passage, Atwater (2000) discusses the additional constraints placed on classrooms that serve low income, African American student populations:

> Upgrading school buildings and science classrooms is only one domain that requires financial resources. Time in the school day devoted to science, exemplary multicultural science teachers, culturally sensitive science curriculum frameworks, and science apparatus and supplies also requires financial resources to fuel science education reform for Black Americans (*National Science Education Standards*, 1996). Many science materials are consumable and need to be restocked regularly. Science equipment, such as microscopes and balances, needs to be upgraded frequently and requires regular maintenance. Print, video, and technology sources of information and simulations also cost money. Finally, the creation and implementation of equitable science education policies require professional teachers, time, and employment of school science leaders (*National Science Education Standards,* 1996) (p. 172).

According to Atwater (2000), urban schools are often more poorly equipped than suburban schools. It is not uncommon to find science classrooms lacking the proper lab equipment, textbooks, and now in more recent years, access to instructional technology (Atwater, 2000). This absence of physical and human resources to support science instruction and supplementary activities, such as science fair projects and science clubs, often creates a greater financial need in urban and rural schools.

Psychological Factors

Even with all other factors held constant, African American students continue to underperform in academic measures such as standardized test scores, college grades and graduation rates. Why does this disparity still exist? Steele (2003) discusses how a phenomenon known as the stereotype threat influences the achievement of African American students. Stereotype threat is described as a social psychological predicament rooted in the prevailing American image of African Americans as intellectually inferior (Aronson, Fried & Good, 2001). Stereotype threat is "the threat of being viewed through the lens of a negative stereotype, or the fear of doing something that would inadvertently confirm that stereotype" (Steele, 2003, p. 253). During my certification program through the Teach for America organization, I participated in a sharing session that allowed and encouraged us as preservice teachers to examine our belief systems about education, schools, and students. One of the other participants cautiously admitted that the absence of African American and other minority students in her higher level mathematics and science courses had caused her to internalize the notion that these groups were indeed less capable of such work. From personal experiences to social media to publications, such as *The Bell Curve*, intellectual ability is closely tied to negative stereotypes of African Americans. In a research investigation conducted by Aronson and Steele, it was found that this stereotype threat did negatively impact the performance of African American students on a test used to measure verbal ability when compared with White students of similar academic ability. Additionally, it was determined that the effects were most pronounced in the most achievement oriented students. Specifically, for students who identified themselves as "good" students or as "smart" were the most impaired by this psychological condition. The experiment revealed that stereotype threat conditions caused African American students to actually try too hard.

Participants reread the questions, reread the answer choices, and rechecked their answers to the extent of inefficiency or paralysis on the academic measure (Steele, 2003).

The science learning of African American students can additionally be attributed to the “disidentification” associated with the “stereotype threat”. Disidentification, a negative consequence of the stereotype threat, is the psychological disengagement from achievement hypothesized to help students cope with stereotype threat and underperformance in a given domain (Aronson, Fried & Good, 2001). According to this phenomenon, African American students focus more energy on athletics, entertainment, and street culture because these are all domains that society tells them are viable options for black youth to achieve success. At the post-secondary level this might influence the decision to pursue a career where African Americans have proven successful, such as education or social work. Reform initiative or models that have proven effective in the teaching and learning of African American students are based on principles that reduce disidentification and build skills based on malleable theories of intelligence. For example, the culturally relevant pedagogy model, developed by Ladson-Billings (1995) encourages teachers to develop relationships and create relevant content materials to promote the behaviors necessary to do well academically. Charter and other high-performing schools are successful because these academic skills are required through performance contracts and structural components like extended day and summer enrichment. Students eventually develop the work ethic and skills necessary to succeed in school, those students who do not will encounter academic difficulty again when the structure or support mechanism is removed.

Factors That Influence Science Learning of Female Students

Females continue to be underrepresented in academic majors and careers in STEM fields. Cronin and Roger (1999) describe this problem as both progressive and persistent because it increases as later stages in the pipeline and has not been reduced despite reform initiatives. The challenges faced by female students parallel many of the barriers faced by African American students, such as multiple intelligences and psychological factors. Hyde (1996) found a statistically significant difference between males and females in the areas of mathematical performance and spacial perception, both are particularly important skills in the study of chemistry. Beasley and Fisher (2012) discuss how stereotype threat affects the test-taking abilities of women in addition to minorities, and influences major life experiences. Despite the commonalities, there are several factors that uniquely influence the science learning of female students: a) experiences in the classroom; and b) perceptions of scientists and science careers.

Experiences in the Classroom

Curricular Materials and Design

Although the representation of males and females in science text is more balanced today, historically sex bias has been a problem in textbooks. Walford (1981) found that that majority of people depicted in illustrations and photographs were male. Sex bias in textbooks can also be problematic in the ways in which problems are worded and the types of examples. Activities that emphasize sports and male-dominated activities may reinforce the notion of science for males. The contributions of women to the field of science must be highlighted in textbooks at the K-12 level and beyond. Other curricular decisions may also be detrimental to female students. Tai and Sadler (2001) found greater achievement for female students in classes that emphasized greater depth of content over breadth, as well as mathematical level (algebra vs. calculus based).

Pedagogy

Despite reform initiatives, there exists a perception among teachers, students, and parents that science is for boys (Blickenstaff, 2005). These notion and ideas about who can be successful in science influences teaching practices. According to Hacker (1991), there are significant differences in classroom interactions for male and female students. Research consistently indicates that girls tend to receive less attention from teachers, regardless of grade level or academic subject. Differences were noted in student feedback, classroom participation, and discipline. Patterns of interaction coupled with the fact that science and math teachers are more likely to be male can perpetuate the belief that science is not for girls.

Perceptions of Scientists and Science Careers

Biological vs Physical Sciences

In one sample of 40 elementary, middle grades, and secondary school age girls, Baker and Leary (2003) found that girls not only liked science, but were confident in their abilities to perform well in science coursework. The girls expressed a preference for the act of "doing science" and an exploration of topics that were relevant and allowed them to help and care for others. Female students made a distinction between the biological scientist and the "scientist scientist" who studies the physical sciences and uses chemicals and electricity.

Difference Feminism

Relationships and relational values, such as cooperation, working with people, and helping others may be important enough to deter interested and capable women from pursuing careers in science. Female students may feel that the power, prestige, and financial compensation that comes along with certain high-status professions would result in a sacrifice of relationships, the ability to have children, long hours and prolonged time in school. Absence of role models in STEM departments and careers may transmit the message that this is not a suitable or enjoyable path for women.

Chapter Summary

This chapter provided a review of the literature relevant to this study. It discussed the basic tenets of Black feminist thought. It also addressed the factors that influence the chemistry learning of students, and provides additional details on specific factors faced by African American and female students. The next chapter introduces the methodology that will be used in this study including the participants, selection process, as well as the research environment.

CHAPTER THREE

METHODOLOGY

In this chapter, I will present a description of the methodology and methods used in this research study. I will discuss the rationale for selecting a participatory action research (PAR) design for this investigation. Then, I will introduce the freshman chemistry program at the research site and the criteria that will be used in sample selection. Next, I will discuss the primary data collection strategy for this study, co-generative dialogue, and the methods that were used for data analysis. Finally, this chapter will address viability and transferability, as well as researcher bias and assumptions.

The purpose of this study was to collectively identify critical issues in the freshman chemistry course and co-generate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Additionally, this research sought to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution. Specifically, this research addresse the following questions:

1. What issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution?

2. What "stories" emerge from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution?
3. What solutions are co-generated by African American female undergraduate STEM students during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution?

Rationale for Qualitative Research Methods

Student interest in STEM majors has remained steady in recent years, but the need for more talent in this area has never been more important. An understanding of the experiences of African American female undergraduate STEM students in freshman chemistry could influence recruitment, retention, and achievement on predominantly White campuses as U.S. demographics continue to shift towards becoming majority "minority" and majority female. Existing research, primarily quantitative in nature, fails to give voice to students and illuminate the unique challenges faced by African American females.

This investigation was appropriate for qualitative inquiry because the goal was to understand the experiences of African American female undergraduate STEM students during freshman chemistry. Creswell (1998) defines qualitative research as "…an inquiry process of understanding based on distinct methodological traditions of inquiry that explore a social or human problem. The researcher builds a complex, holistic picture, analyzes words, reports detailed views of informants, and conducts the study in a natural setting" (p. 15). Creswell (1998) outlines eight characteristics of qualitative research: (a) natural setting as source of data; (b) researcher as key instrument of data collection; (c) data collected as words or pictures; (d) outcome as process rather than product; (e) analysis of data inductively; (f) focus on participants' perspectives; (g) use of expressive language; and (h) persuasion by reason (p. 16).

Unlike reliance in quantitative research on numbers and statistical analysis, qualitative research provides thick, rich descriptions using words and narratives. Great care is taken to preserve the voice of the participants in the study, who are often silenced or marginalized in other types of research. Qualitative investigations focus on the process by which change and transformation occur in the lives of the research participants, understanding the importance of experiences in addition to final products (Bogdan & Biklen, 2007). Rather than derivation of a conclusion based on previous knowledge or assumptions, qualitative researchers remain open at the start of an investigation and allow meaning to be constructed as patterns emerge from the data collection process. At the heart of qualitative research is the desire of qualitative researchers to understand the meanings individuals make out of specific events and experiences in their lives. This meaning-making process can be used to inform interventions, policies, and organizational practices in order to improve society (Bogdan & Biklen, 2007).

After careful consideration of the rationale presented by Creswell, qualitative research was the most appropriate methodology to use in this investigation of the experiences of African American female undergraduate STEM students in freshman chemistry at a predominantly White institution. The increasing numbers of African American female students in undergraduate programs, coupled with the importance of mastery in the freshman chemistry course to future science study, makes this a vitally important area of research, particularly for STEM programs hoping to attract and retain these individuals.

Qualitative Research Design

Creswell (1998) offered several compelling reasons why a researcher would choose to engage in a qualitative study and the characteristics of "good" qualitative study (p. 20). One of these characteristics is that the researcher "identifies, studies, and employs one or more traditions of inquiry" (p. 21). The research tradition is the foundation of the qualitative research design with correlating data collection and data analysis techniques. This study's research tradition, participatory action research (PAR), was selected because the goal of this research investigation was to "produce practical knowledge that is useful to people in the everyday conduct of their lives" and to "increase the well-being of human persons and communities" (Reason & Bradbury, 2001, p. 2). This study sought to identify concerns of African American female STEM undergraduate students enrolled in the freshman chemistry course at a predominantly White institution and co-generate solutions to improve the quality of teaching and learning and academic outcome for this population.

Participatory Action Research Tradition

Participatory action research (PAR) is defined as "research which involves all relevant parties in actively examining together current action (which they experience as problematic) in order to change and improve it" (Wadsworth, 1998, p. 10). The characteristics of action research are grounded in a participatory worldview and to the action researcher "objective knowledge is impossible, the researcher is always part of the world they study" (Reason & Bradbury, 2001, p. 8). There are several key components that make up PAR: a) a focus on change; b) context-specific; c) collaboration; d) a cyclical process; e) involvement of participants; f) knowledge generation; g) liberatory; h) orientation over method; and i) criteria for success (Graham, 2008).

Focus on change. Participatory action research is designed to serve different purposes from traditional academic research. Rather than the development of new theories, PAR shifts the focus to practical outcomes and the development of new forms of understanding about the world (Reason & Bradbury, 2001). This research on African American females in freshman chemistry sought to co-generate solutions to improve the quality of teaching and learning and academic outcome for this population. The focus of this study was on change at both the individual and community level. Through participation in these c-ogenerative dialogue sessions, it was the hope that participants would gain new insight regarding their experiences in freshman chemistry. Additionally, these sessions generated solutions to address specific concerns related to the course that could potentially lead to immediate change in the academic behaviors and feelings about the course. By sharing research findings with chemistry faculty and department administration, this research also sought to initiate systemic change in the freshman chemistry course.

Context-specific. Participatory action research is context specific, targeting the needs of a unique group or community rather than generalizations about a larger population. The target population for this research investigation was African American female undergraduate STEM students enrolled in the freshman chemistry course at a predominantly White institution. This analysis of the interlocking nature of oppression "shifts the entire focus of investigation from one aimed at explicating elements of race or gender or class oppression to one whose goal is to determine what the links are among these systems" (Collins, 1986, p. 20). This more traditional approach has proven to be problematic in that it "prioritizes one form of oppression as being primary, then handles remaining types of oppression as variables within what is seen as the most important system" (Collins, 1986, p. 20). This analysis was important for this investigation given the academic challenges experienced by African American females in the freshman chemistry course.

Collaboration. While the extent to which collaboration occurs from one research study to another varies, participatory action research places a significant emphasis on collaboration. This research utilized co-generative dialogue sessions among Black females to allow these participants to collectively identify critical issues in the freshman chemistry course and co-generate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Co-generative dialogues are a form of structured discourse that allow all stakeholders to work collaboratively to generate solutions about a shared event of experience (Martin, 2006; Tobin, 2014; LaVan, 2004).

A cyclical process. Participatory action research is comprised of participation, action, and research occurring in an iterative cycle. Wadsworth (1998) describes PAR as a cycle, "starting with reflection on action, and proceeding round to new action which is then further researched" (p.3).

Participant involvement. While the level of participation may vary, a central theme to PAR is the involvement of participants in the entire research process. By actively engaging participants, PAR "challenges the status of researchers as experts" (Graham, 2008). According to Reason and Bradbury (2001), PAR is "only possible with, for, and by persons and communities, ideally involving all stakeholders both in the questioning and sense-making that informs the research and in the action which is its focus" (p. 2). The use of co-generative dialogues as a primary data collection method allowed for a greater degree of participant involvement. According to Tobin (2014), "all participants are regarded as having equal power in the cogen field" (p. 184), so participants' voices were honored in the initiation of session topics, location of sessions, scheduling of sessions, etc.

Knowledge generation. One of the goals of PAR is "produce practical knowledge" (Reason & Bradbury, 2001), as well as to raise questions about how knowledge is generated (Graham, 2008). These goals of PAR are consistent with both the theoretical and methodological framework used in this study. Black feminist thought strives to develop "facts and theories about the Black female experience that will clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16). Co-generative dialogues seek to cogenerate solutions to problems identified in the freshman chemistry course.

Liberatory. Participatory action research is described as emancipatory, leading "not just to new practical knowledge, but to new abilities to create knowledge" (Reason & Bradbury, 2001). According to Graham (2008), PAR seeks to 'liberate' participants by creating an "awareness of their situation" that will drive "collective action". Offering Black females new knowledge about their own experiences can be empowering, but revealing new ways of knowing that allow Black females to define their own reality has far greater consequences (Hooks, 1981).

Orientation over method. Graham (2008) describes PAR as an "orientation to inquiry" rather than "just another method". Researchers can employ either qualitative or quantitative methods. While Wadsworth (1998) recognizes the conceptual differences between participation, action, and research, the three elements that comprise participatory action research, she emphasizes how these differences fade during the shift from theory to practice. Graham (2008) notes that it is the "interaction" between the elements "that gives PAR its distinctiveness".

Criteria for success. How does one measure the success of research in academia? Perhaps by the development of new theory or expanding knowledge in the current research literature. The goals of PAR may be different, often success is measured by some "personal or collective change (Graham, 2008). Unique goals may also lead to different approaches to communicating the findings of research.

Participatory action research was a fitting qualitative research tradition for this exploration of the critical issues and experiences of African American females in freshman chemistry. It was also complimentary as a methodological framework to the Black Feminist Thought theoretical framework.

Data Sources

Research Context

The research site for this study was the University of Georgia, a predominantly White institution located in the southeastern United States. It is a large, public university classified as research intensive (R1) under the Carnegie Classification of Institutions of Higher Education. According to the university's Office of Institutional Research (OIR); a total of 34,536 students were enrolled in 2013, on and off campus. On- campus enrollment was 26,278 undergraduate students and 8,258 graduate/professional students. Total full time faculty comprised 78 % (1,387) White, 10% (178) Asian, 6% (101) Black, 4% (68) Hispanic, and 0.3% (5) American Indian. Also, according to the OIR the student population at University of Georgia encompassed the following: White students, 71% (24,384); Asian students, 9% (3,210); American Indian students, 1% (35); Hispanic students 5% (1,662); Hawaiian/Pacific Islander, 1% (35); and other students, 7% (2,469). African Americans comprise 8% (2,741) of the student population. The student population included 43% (14,773) male students and 57% (19,719) female students. The freshman class consisted of 5,150 students with an average SAT score of 1280 and an average GPA of 3.86.

There are three freshman chemistry courses typically offered to undergraduate students at University of Georgia. CHEM A is a non-mathematical-based study of chemical principles with an emphasis on environmental issues. This course is intended for students who have an interest in chemistry, but who are non-science majors. CHEM B explores introductory chemical principles including stoichiometry, structure, bonding, and kinetics. This course is math intensive and is designed for students who plan to major in science, engineering, agriculture, forestry, or a pre-professional program (pharmacy, medicine, dental, and veterinary science). CHEM C is the most rigorous course offered to chemistry majors and is only available with permission of the department. This research investigation will focus on the CHEM B course.

In the fall of 2014, there were approximately 3337 students enrolled in CHEM B course. There were 296 (9%) African American students, 210 (71%) were female, and 86 (29%) were males. African Americans females were more likely to withdraw from the course than any other group (26.7%). The students who opted to remain in the course earned a smaller percentage of A's and B's (31.5%) in the course than any other group except African American males (25.6%). Additionally, African American females and African American males earned a greater percentage of C's, D's, and F's, 41.9% and 55.9%, respectively.

In the fall of 2014, the chemistry department began offering a fourth introductory chemistry course, CHEM D. This course was designed to meet the needs of freshman students who would benefit from additional instruction in the basics of chemistry and in developing problem-solving skills and strategies. Incoming freshman were encouraged to complete a Chemistry Diagnostic Test (CDT) during the summer of 2014. The CDT consists of 30 questions and students were allotted 60 minutes for completion. Students and advisors use CDT scores to inform their decision to register for CHEM B. The CDT scores range from 0 to 30. All students scoring 13 and below are encouraged to enroll in CHEM D. Each student makes the final decision and students can still opt to enroll in CHEM B, especially students concerned about the timely completion of graduation requirements. Additionally, students performing poorly in CHEM B are able to "drop back" into the CHEM D course for credit rather than face withdrawal or failure in the CHEM B course. During the fall semester of 2014, approximately 200 students enrolled in CHEM D course. The development and implementation of the CHEM D course targeted the same "at risk" population that is of interest to this research investigation, therefore this new option could reduce the pool of potential candidates.

Sample Selection

In selecting African American female undergraduate STEM students as the focus of this investigation, I considered whether to use a random or purposeful sample. According to Patton (2002), "random sampling is the appropriate strategy when one wants to generalize from the sample studied to some larger population (p. 100). In contrast, "purposeful sampling is used as a strategy when one wants to learn something and come to understand something about certain select cases without needing to generalize to all such cases" (Patton, 2002, p. 100). The goal of this research study was to gain an understanding of the experiences of African American female STEM students in freshman chemistry, not on generalization of findings.

Sample Selection and Criteria

Merriam (1998) emphasized the importance of selecting "a sample from which the most can be learned" (p. 12) in a qualitative inquiry. I used a purposeful sampling to obtain the richest data available that was related to the purpose of this study. All participants chosen to participate in this study met the following criteria:

- Identified as an African American or Black;

- Identified as a female;
- Were enrolled in the CHEM B course at University of Georgia;
- Were willing to participate in 3-4 co-generative dialogue sessions;
- Were willing to participate in an individual interview;
- Were willing to select 2-4 photos to be discussed during interview
- Added diversity to sample; race and gender were homogeneous so variation was desired in other characteristics, such as educational background, family background, and socioeconomic status, and course grades.

Sampling Procedure

Initial participants were recruited through visits to course lectures, by faculty members and teaching assistants, and advertisements (Appendix A) on campus bulletin boards. Advertisements were strategically placed in the entryways to the science learning center, chemistry building, chemistry resource center, and residence halls where chemistry tutorials are available. Referrals were sought from professors, teaching assistants, and advanced students who tutored freshman chemistry using a snowball method of selection. Interested persons were directed to contact me by phone or email. Following this initial correspondence, potential participants were contacted by phone so that I could explain the study and conduct a brief telephone interview. I used a screening tool (Appendix B) to determine if the participants meet the criteria for the study. I also collected demographic data at that time. The screening tool focused on academic major, educational background, and family background to allow me to select a diverse sample. Since race and gender will be homogeneous among the participants, I focused on variation in other characteristics, such as educational background, family background, and socioeconomic status, and course grades.

I also used a purposeful sampling strategy known as network sampling. Network sampling, also referred to as snowball or chain-referral sampling, is a qualitative research method that "yields a study sample through referrals among people who share or know of others who possess some characteristics that are of research interest" (Biernacki & Waldorf, 1981, p. 141). African American females currently comprise less than 10% of the students enrolled in the CHEM B course, representing a hidden or "hard to reach" population (Biernacki & Waldorf, 1981; Goodman, 2011; Heckathorn, 2011) commonly targeted through network sampling. To better facilitate the recruitment process, participants were educated on the eligibility criteria and specific research needs (Biernacki & Waldorf, 1981).

Data Collection

Primary Data Sources

I began data collection in the fall of 2017. The primary data collection method for this basic, interpretive qualitative design was co-generative dialogue sessions. Co-generative dialogue or cogen "offers teachers and their students a methodological and theoretical framework for engaging in meaningful research in their own classrooms (Martin, 2006, p. 695). Co-generative dialogues are a form of structured discourse that allow all stakeholders to work collaboratively to improve the quality of teaching and learning in an academic setting (Martin, 2006). The term "cogen" evolved out of the intended outcome of this activity. The "co" means together and "gen" comes from the word generate (Tobin, 2014). Cogen consist of two or more individuals having a structured conversation about a shared event or experience (LaVan, 2004). Co-generative dialogues when properly implemented can benefit students and teachers for many reasons. It can shift the power differential in the science classroom by empowering students to share the responsibility for making and sustaining change. Cogen initiates student contributions that are both valuable and valid, leading to a productive means of improving learning experiences. Additionally, when dialogue occurs across achievement borders it allows students an opportunity to "recognize that individual student experiences with and in science (and school) differ from one to another" (Martin, 2006, p. 716).

Over the course of the academic year, five participants engaged in co-generative dialogue sessions alongside the researcher. Each participant signed an informed consent form (Appendix C) during their first cogen session. The consent form explained the research, their rights as participants, as well as the risks and benefits of participation in the research study. During this session, I provided background information related to the research study and my own experiences as an African American female STEM undergraduate and graduate student. The guidelines and protocol for cogen sessions were shared (Appendix D). Cogen sessions ranged from approximately 60 to 120 minutes in length. I audio recorded all session using Audacity, a free audio editor and recorder software program. I also used a portable voice recorder as a backup device. I typed each recording to create a written transcript of the data.

The first cogen session followed a prepared agenda (Appendix E) to brainstorm key issues or "identify contradictions that might be changed with the goal of improving the quality of teaching and learning" (Tobin, 2014, p. 182). Martin (2006) also discusses the need to address "more subtle issues in the classroom" that often have minimal impact on student achievement or behavior, but that can significantly impact student interactions with teacher or the subject matter (p. 699). Subsequent sessions focused on structured and collaborative dialogue sessions to cogenerate solutions to identified issues. An inductive process was used to develop content for the sessions, and topics included assessment, communication, structure, and pacing of the course. According to Tobin (2014), "all participants are regarded as having equal power in the cogen field" (p. 184), so participants' voices will be honored in the initiation of session topics, location of sessions, scheduling of sessions, etc.

Secondary Data Sources

In addition to the co-generative dialogue sessions, I also used secondary data sources: a) interviews; and b) photo elicitation.

Interviews. Another data collection method for this participatory action research design was semi-structured individual interviews with each participant. "Qualitative interviews are used when researchers want to gain in depth knowledge from participants about particular phenomena, experiences, or sets of experiences" (deMarrais, 2004, p. 52). This conversation was intended to build a rapport with the participants, thus allowing for a more candid and richer discussion about the research topic. Additionally, I learned more about the unique backgrounds and experiences of the participants and identified issues or concerns related to the course that were not shared during the cogen sessions (see Appendix F for interview protocol). This information was another resource in the development of topics for future cogen sessions. Interviews were approximately 60-90 minutes in length. I audio recorded all interviews using Audacity, a free audio editor and recorder software program. I also used a portable voice recorder as a backup device. I typed each recording to create a written transcript of the data. I employed a semi-structured interview format with open-ended questions. Roulston (2010) described the semi-structured interview process:

> In these kinds of interview, interviewers refer to a prepared guide with a number of questions, these questions are usually open-ended, and after posing each question to the research participant the interviewer follows up with probes seeking further detail and description about what has been said…[E]ach interview will vary according to what was

said by the individual interviewees, and how each interviewer used follow-up questions to elicit further information (p. 15).

Photo-elicitation. Elicitation techniques use visual, verbal, or written stimuli to encourage people to share their ideas (Johnson & Weller, 2002) and provide "useful alternatives to direct questions about participants' thinking, particularly when social, cultural, or psychological barriers make it difficult to talk about a topic" (Barton, 2015).

Timeline for Data Collection

Recruitment began during the first week in September. There were a total of 4 cogen sessions held during the fall semester. One session was held each month during the months of October, November, and December. The final session took place during the first week of January. This final activity provided an opportunity for participants to reflect on the chemistry class after they had completed all of the academic tasks and were aware of their final grade in the course.

Table 1
Timeline for Data Collection

	Week 1 (1st – 7th)	Week 2 (8th – 14th)	Week 3 (15th- 21st)	Week 4 (22nd -28th)	Week 5 (29th – 31st)
August			1st Day of Classes	Exam 1	
September	Recruitment Begins	Exam 2			
October		Exam 3	1st Cogen Session		
November	Exam 4	2nd Cogen Session		Exam 5	
December	3rd Cogen Session	Final Exam (12/13)			
January	4th Cogen Session				

Recruitment for the second study began in February. There were a total of 2 cogen sessions held during the spring semester. One session was held during the months of March and April. The final activity took place during the first week of June.

Table 2 Timeline for Data Collection – Spring Semester					
	Week 1 (1st – 7th)	Week 2 (8th – 14th)	Week 3 (15th- 21st)	Week 4 (22nd -28th)	Week 5 (29th – 31st)
January		1st Day of Classes		Exam 1	
February	Recruitment Begins	Exam 2			
March		Exam 3	1st Cogen Session		
April	Exam 4	2nd Cogen Session		Exam 5	
May		Final Exam (5/2)			

Data Analysis

Data analysis is a critical component to qualitative research. Patton (1990) described the analysis process as both an "art" and a "science." According to Corbin and Strauss (2008), "the art aspect has to do with the creative use of procedures to solve analytic problems and the ability to construct a coherent and explanatory story from data, a story that "feels right" to the researcher" (p. 47). The "science" comes from the systematic and organized manner in which the data are scrutinized to develop concepts and themes (Corbin & Strauss). "Quality in qualitative research is something we recognize when we see it; however, explaining what it is or how to achieve it is much more difficult" (Corbin & Strauss, 2008, p. 297). Creswell (1998) outlines specific procedures to ensure that standards of quality and verification are achieved in qualitative research. According to Corbin and Strauss (8), there are eight conditions that nurture the development of quality research: (a) "methodological consistency"; (b) a clear purpose; (c) self-awareness; (d) training in qualitative research; (e) sensitivity for the topic, participants, and the research; (f) a willingness to work hard; (g) "methodological awareness"; and (h) a desire to do research (p. 302-304). In this section, I will outline my strategy for data analysis.

Analysis Methods

According to Charmaz (2006), the research process is not linear, but more of a circular one. The constant comparative method developed by Glaser and Strauss (1967) requires a constant comparison of data for similarities and differences. This comparison occurs within the same session, between different sessions, and across subsequent sessions. The data collection and analysis process occur simultaneously. During the data collection process, the researcher will "raise questions that emanate from thinking about our collected data and shape those data we wish to obtain" (Charmaz, 2006, p. 3). There were three main components to my data analysis process: (a) organization of collected data; (b) development of themes or patterns; and (c) final representation of findings (Creswell, 2007). I read each transcript to obtain a general description and to reflect on their overall meaning. I coded the transcripts to generate a description of the participants, categories, and began theme analysis in order to generate themes from the data. I also listened to the recorded interviews to capture information that cannot be captured from the written document. I used Microsoft Word as my primary tool used for analysis, specifically the "cut" and "paste" functions and "highlight" feature.

"Coding is the first step in moving beyond concrete statements in the data to making analytic interpretations" (Charmaz, 2006, p. 43). According to Charmaz (2006), two main components make up the grounded theory coding process: (a) an initial phase to code smaller segments of data; and (b) a more focused phase that builds on initial codes to organize larger amounts of data. This analysis phase allowed me to make meaning of the data. During this process, unexpected patterns may emerge leading to new research questions to be addressed in subsequent cogen sessions. I performed a line by line analysis by dissecting each line of the written data. This approach allowed me to maintain a fresh perspective to the significance of specific data without overlooking subtle nuances often missed when reading written text as part of a larger narrative.

Viability and Transferability

According to deMarrais (2004), U. S. policies may serve to increase questions related to the trustworthiness of qualitative research. deMarrais (2004) described the problems created by over reliance on scientifically-based research and quantitative research, “as an insistence on these inappropriate measures of quality discounts those qualitative approaches to research that are best suited for examining the highly unique processes of education within particular contexts that are not amenable to replication and generalization across sites, cities, schools, specific groups of children, and teachers within a diverse society“ (p. 288). Validity and reliability exist in qualitative research to allow researchers to understand the lives and experiences of participants in the study (Patton, 2002). It is important to address validity and reliability so that all stakeholders can trust the end products of qualitative research (Rossman & Rallis, 2003).

Internal Validity

Internal validity is defined as how closely research findings match the actual experiences of the research participants. According to Merriam (1998), “internal validity asks the question, how congruent are one’s findings with reality” (p. 25). Creswell (1998) presented a number of strategies commonly used by qualitative researchers to ensure the internal validity of a study including triangulation, member checks, peer reviews, statement of researcher bias, and prolonged time in the field. In this study, I used data source triangulation. According to Bogdan and Biklen (2007), triangulation is defined as “using multiple subjects, multiple researchers, different theoretical approaches in addition to different data-collecting techniques” with the rationale that “many sources of data were better in a study than a single source because multiple sources lead to a fuller understanding of the phenomena” (p. 113-114). I used member checks as another strategy. Member checks occur when participants are asked to “comment on your interpretation of the data” (p. 26). I shared preliminary findings with research participants at various points during the study to gauge the extent to which I had captured their experience. According to Merriam (1998), “all graduate students have a peer review process built into their thesis or dissertation committee, as each member reads and comments on the findings (p. 26). I used this peer review process to bolster the internal validity of my study as each member of my committee had varying degrees of familiarity with the field of science education and my research topic. I also used prolonged time in the field. The data collection phase continue over the course of the academic year until the point of saturation.

External Validity

External validity, referred to as reader or user generalizability, reflects the extent to which descriptions are rich enough to allow the reader to apply it to their specific situation. According to Merriam (1998), “if one thinks of what can be learned from an in-depth analysis of a particular situation or incident and how that knowledge can be transferred to another situation, generalizability in qualitative research becomes possible” (p. 28). Strategies commonly used by qualitative researchers to ensure the external validity of a study are rich descriptions, maximum variation in sampling, audit trails, and researcher journals. Eisner (1998) offers a brilliant analogy to this concept of generalizability in the following quote: “For qualitative research, this means that the creation of an image, a vivid portrait of excellent teaching, for example can be a prototype that can be used in the education if teachers or for the appraisal of teachers" (p. 199). In this study, I used rich, thick descriptive data as a major strategy to ensure external validity (Merriam, 1998). I also used maximum variation of my purposeful sample. While certain elements of my sample created a degree of homogeneity, in an effort to maximize variation I sought variation in other characteristics, such as educational background, family background, academic major, and parental educational level.

Reliability

According to Merriam (1998), from a quantitative perspective, reliability refers to the replicability of research findings, but the qualitative researcher is concerned with "whether the results are consistent with the data collected" (p. 27). Creswell (1998) discussed reliability as a "dependability that the results will be subject to change and instability" and a confirmation "in establishing the value of the data" (p. 198). Triangulation, peer review, and statement of research bias are all methods I used for internal validity that also support reliability.

Researcher Bias and Assumptions

The American Association for the Advancement of Science (AAAS) published its ground breaking report *The Double Bind: The Price of Being a Minority Woman in Science* in April of 1976. The report highlighted the extent to which African American women in the sciences have historically faced challenges associated with both race and gender, creating what has been referred to as a double bind (Malcom, Hall, & Brown, 1976). I was born a year and a half later in the Fall of 1977, making me a member of the "next generation of scholars" seeking to understand the full impact of this double bind on African American females' interest, persistence, and success in STEM careers. My perspective has been shaped by a variety of roles including as a STEM undergraduate student, practicing engineer, K-12 science teacher, and now as an education researcher. As an African American female immersed in a world of STEM, I can honestly say that I have lived my life in this “double bind.”

My personal and professional experiences come together to create several assumptions and biases on my part. I believe that the research surrounding why students leave STEM majors accurately portrays my experiences and those of others. Poor quality of science instruction, impersonal relationships, tremendous workloads, and detached academic advisement experiences create a very unwelcoming climate. I have observed friends and classmates transition from STEM to non-STEM majors as a result of poor grades, feelings of inadequacy and unsupportive environments. Despite some negative experiences, it is still my personal belief that my undergraduate STEM degree has proved beneficial. I have experienced a greater variety of opportunities and more financial compensation and job security than many of my friends with social science backgrounds. The critical thinking and problem-solving skills that I acquired during my engineering program have been valuable in a variety of settings. I would certainly encourage any student with an interest in STEM to persist in this field.

As a classroom teacher, I have observed that many of my students are intimidated by the work requirements and difficulty level of advanced science and math topics. I have watched countless students experience academic difficulty in a variety of courses and settings. I believe that more than other factors, it is how students respond to this adversity that determines the academic outcome. I also believe the actions, behaviors, and words of an instructor can work to either motivate or discourage struggling students. My academic experiences as an undergraduate and graduate student are closely aligned with Black feminist theory, and I believe my personal experiences at predominantly White institutions have been uniquely shaped based on my identification as an African American female.

My role as a member of the STEM community has given me access to information, people, and events that are not usually available to "outsiders." It also gives me greater understanding of the academic demands and pressure placed on students who pursue STEM majors. My background in education gives me an understanding of the best practices in education that can promote better performance in chemistry and other STEM courses. My assumptions and biases have been the impetus for this research project. Although I cannot eliminate my assumptions and biases that I bring to this research, I have attempted to minimize them throughout this process to ensure that my findings reflect the experiences and voices of my participants.

Limitations

Every research study has limitations inherent to its design. For this qualitative study, several limitations must be taken into account. This study has informed our knowledge of African American female students and their academic experiences in freshman chemistry at University of Georgia, but may not reflect the experiences when other factors including race, gender, content area, and/or university setting are altered. Another limitation of this study is related to the use of cogenerative dialogue sessions and individual interviews as the data collection methods. Participants self-reported information related to their academic experiences, such as examination scores and academic interventions. All of this information will only be reliable to the extent that the participants are honest and can accurately recall the events and emotions related to the chemistry class. Another significant limitation was the lack of participation of the chemistry faculty and administration in the dialogue sessions. The absence of these stakeholders may decrease the effectiveness of cogenerated solutions and our collective ability to initiate timely change in the chemistry course.

Chapter Summary

This chapter presented a description of the methodology and methods used to conduct this research. I discussed the rationale for selecting a basic, interpretive qualitative design for this investigation. It included sections on sample selection and criteria, data collection and analysis, validity and reliability, and researcher bias and assumptions. The next chapter will offer thick, rich descriptions of the research participants, as well as the results of this research study.

CHAPTER 4

RESEARCH FINDINGS

The purpose of this study was to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Additionally, this research sought to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution. Black Feminist Thought was used as the theoretical framework for this study as it sought to develop "facts and theories about the Black female experience that will clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16).

This research investigation consisted of two distinct cases; one conducted during the fall semester and one conducted during the spring semester. Each case consisted of African American female undergraduate students who were enrolled in the same freshman chemistry course at University of Georgia. All students participated in a series of co-generative dialogue sessions and an individual interview. In order to analyze each case, data was generated from co-generative dialogue sessions, individual interviews, participant questionnaires, and instructional materials.

Using a participatory action research (PAR) approach, the research participants strive to generate possible solutions and interventions to promote greater success in the freshman chemistry course among African American female students and other "at-risk" populations. In this chapter, I will describe the findings from my data collection and analysis process, beginning with a description of the context for each case. Next, I will discuss the critical issues associated with the course and potential solutions to these concerns. Finally, I will highlight the most salient themes that "emerged" from both cases. The major themes from case one are: a) isolation; b) relationships with faculty; and c) role of social networks and support systems. The major themes from case two are: a) resistance to a weed out culture; and b) racial experiences and a lack of diversity. The chapter ends with a cross-case analysis to further our understanding of the unique experiences of African American female students in freshman chemistry course at a predominantly White institution.

Context for Case One

Case One was conducted primarily during the fall semester at the University of Georgia. It was the first semester of each participant's freshman year of college. This is notable because research indicates that this period marks a significant transition from childhood to adulthood. Freshman students have to adjust to a new environment often away from friends and family, live independently, and learn to manage academic responsibilities. Perry, Hladkyj, Pekrun, and Pelletier (2001) have described a phenomenon called the "paradox of failure" when previously successful high school students experience academic difficulty for the first time in college as a result of the "increased demands for self-initiative and autonomy" (p. 776). Data collection began in October 2017 and concluded in January 2018. It consisted of 4 co-generative dialogue sessions, individual interviews, and a photo-elicitation exercise. The co-generative dialogue sessions and individual interviews took place on Sunday afternoons in Aderhold Hall. The research participants included 3 African American female undergraduate students enrolled in Chem B; Nicole, Marie, and Rickel. Each participant lived in a dormitory on campus. Both Marie and Rickel were pursuing a pre-medicine professional program, but their respective majors were Public Health and Biology. Nicole had declared a biomedical engineering major and planned to pursue a master's degree in business administration. Rickel and Marie were both enrolled in an evening section of Chem B taught by Professor Gilbert. Nicole was enrolled in an afternoon section taught by Professor Young.

During the data collection, several similarities were noted among the research participants. First, all of the students expressed a love and interest in science, as well as the desire to pursue a career in STEM. Nicole articulated this belief during our introductory session saying, "Well, I love science I've always loved science and math has been my strongest subjects ever since I could remember, but I don't understand why chemistry is giving me such a hard time now." And Rickel shared a similar belief, "Well I've always been science oriented like she has I've pretty much since I was a young girl I always knew I wanted to be in like the science field or whatever so like I interned at Georgia Tech and like I did all these science classes just to get extra credit in high school." They also discussed challenges associated with the course including a difficulty adjusting to the workload, pace, and course structure. Additionally, all of the students were educated in the metro Atlanta area, grew up in a home with both parents, and reported that at least one parent was employed as a teacher at the K-12 level. Despite similarities, in agreement with Black Feminist Thought, rich differences among these participants offered a greater context to truly make meaning behind the experiences of Black women. These differences related to family background, educational background, chemistry background, and socioeconomic status.

Critical Issues

One of the primary goals of this research investigation was to identify critical issues raised by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution. There were a number of issues related to the freshman chemistry course introduced by the research participants that can be classified into three categories: a) instructional methods; b) assessments; and c) course resources.

Instructional Methods

Instructional methods were a significant area of concern for students during the co-generative dialogue sessions. Instructional methods are defined as strategies, activities, or procedures for teaching or supporting learning in an academic setting. Initially, the participants expressed a desire for additional instructional time for students to develop foundational chemistry skills, but later participants stated that students would benefit from better use of the current instructional time. Marie described periods of down time during class while students were working on practice questions individually or in small groups:

> I think a lot of the time it's just wasted in that class you asked like yes like five questions five to seven questions I think in total class and most of us are just sitting there like what's going on (Marie, cogenerative dialogue session, October 22, 2017)

Marie offered a comparison to her experience at Georgia State University taking chemistry as part of her dual enrollment program:

> I know at Georgia State I like we did probably the same amount of time I went twice a week probably for an hour each and we got everything done I learned everything fully they were lecturing the whole time it wasn't just okay go answer this question you have 10 minutes I'll come back later. (Marie, cogenerative dialogue session, 10/22/17)

Additionally, Marie shared a belief that the majority of students did not find lecture to be helpful and would be less likely to attend if the department did not utilize the clicker system to track attendance and assign bonus points:

> Yeah no yeah it’s not productive and people would not go to class if it was not for the clicker questions. (Marie, cogenerative dialogue session, 10/22/17)

Marie expressed that learning activities did not improve her understanding of the content:

> She's actually been doing these things online we have to bring your computer to class and do these worksheets I guess but they're like worksheets online and then you turn them in for participation credit I think same thing she just signs in at the beginning of class, says get in groups, do it, turn it in, there's no going over it, she just walks up and down the stairs waiting for people to ask questions but there's no like learning involved. (Marie, cogenerative dialogue session, 10/22/17)

Students described a non-traditional instructional delivery method or “flipped” classroom that no longer included formal lectures. There seemed to be a general preference for the lecture method with frequent comparisons to the way content was presented in previous chemistry courses. Again Marie was able to draw a contrast between the instructional methods used in her course at Georgia State University:

> I know at Georgia State they lectured you in class taught you how to do everything and you take in class quizzes in class and it made it a lot easier instead of learning everything on your own. (Marie, cogenerative dialogue session, October 22, 2017)

Although the larger class sizes were not ideal, class size was not thought to be a problem with traditional delivery methods or a barrier to learning:

> I feel like even if there is a lot of people in class, you can still lecture (Marie, cogenerative dialogue session, October 22, 2017)

The most troubling comment made by Marie was the belief that she was not learning anything from her chemistry professor or during chemistry lectures:

They are not teaching like she doesn't my teacher at least hasn't taught me anything (Marie, cogenerative dialogue session, October 22, 2017)

In the freshman chemistry class at University of Georgia, students were expected to study content materials outside of class using a digital learning tool, Cengage Mindtap. While in class students worked individually or in small groups to solve a series of clicker questions. Clicker questions were believed to be problematic as students described the questions as being situated in "real-world" scenarios that were confusing. Nicole explained,

I don't understand why chemistry is giving me such a hard time now I think it's because the problems and how they word it it's in a different sense like they're making it real-world situations that you've never really thought of so when I'm working the problems and doing it on Mindtap I understand it but then when I get to clicker questions it might take me a while or I don't get it off the bat" (Nicole, cogenerative dialogue session, October 22, 2017). Similarly, Marie noted:

It's like a whole different completely different type of learning I guess the book isn't too bad itself like when I'm doing problems in the book I understand and I can get good grades on those and then you go in class and the clicker questions just make no sense to me just the way I think it's the way it's worded. (Marie, cogenerative dialogue session, October 22, 2017). She explained further how,

The way its worded especially in clicker questions it's just so hard to like understand what it's even asking you to do because I mean doing a book it just seems so easy then you get in the class and it's not the same thing (Marie, cogenerative dialogue session, October 22, 2017)

Marie also expressed her frustration with the lack of support system to work on problems during designated time in class. Marie complained that the proper way to solve clicker questions was rarely demonstrated and when they were explained it was in a very cursory manner, but only if the majority of students missed the question:

> The clicker questions and then it lets say like a majority of class gets a question right there's no going over the question at all it's okay you guys did good next question and if the majority got it wrong sometimes she'll go through it really quickly and just explain that one problem but that's it that's all we get. (Marie, cogenerative dialogue session, October 22, 2017)

Participants in this study also described some notable differences between the different lecturers for the course. Nicole explained her professor's normal use of clicker questions and the procedure for students needing additional assistance:

> The clicker questions every now and then he doesn't go over why the answer is correct and I'm lost and then I have to you know ask you know ask the person next to me so why is that the answer like why is it the right answer she but she may not know I ask him he may tell me but it's not it's not helpful so every now and then I go to office hours and I asked him about that specific clicker question in it and in office hours he does go over it and tells me why the answer it is and explains it there but in class it's he does go fast if he does talk about or explain the answer why it's right he may do it quickly and I may not get it as quick but that's only for some answers or some questions (Nicole, cogenerative dialogue session, October 22, 2017)

According to Nicole, students in need of additional help were often encouraged to stay after class or attend office hours. It is important to note that many undergraduate students have schedule conflicts that do not allow them to stay behind after lecture and/or attend office hours. While the chemistry laboratory is a separate course at University of Georgia, it could best be described as a missed opportunity as participants in this study did not feel that it was closely aligned to the lecture or helpful to their understanding of the lecture content. Nicole expressed a strong desire to have direct assistance in learning the chemistry content:

> I would just really like to be sat down and taught, walked through problems and that would help me because how they write the problems how they formulated is different (Nicole, cogenerative dialogue session, October 22, 2017)

Rickel also noted that there were limited opportunities to seek assistance in class as there were too many students and only one professor:

> I wish they were like TAs also in our classes like to help us because there's only one Gilbert like she can't be like everywhere and there's usually a lot of questions (Rickel, cogenerative dialogue session, October 22, 2017)

While instructional methods were identified as an area of concern during the cogenerative dialogue sessions, assessments were also discussed as an important factor in the student experience and academic outcome in the chemistry course. The next section discusses the course grading structure and the assessment methods.

Assessments

Assessments was another issue raised during the co-generative dialogue sessions. The term assessment refers to the wide variety of methods or tools that educators use to evaluate, measure, and document the academic readiness, learning progress, skill acquisition, or educational needs of students. Final course grades were assigned based on 5 components: course exams, reading assignments, progress checks, clicker questions, and the American Chemical

Society (ACS) final exam. Of the 1600 points available in the course, 1300 of those points or about 80% were based on students' performance on course exams. The grading structure for the Chem B course is outlined below:

Table 3: Grading Structure

Assignment	Total Points
Five exams	900
Final Exam (ACS)	400
Reading Assignments (eBook)	75
Progress Checks (WebAssign)	150
In-class Clicker Questions	75
	1600

Marie discussed this structure and her belief that it was too heavily weighted on exam performance:

> We don't have..I guess we have progress checks, but we don't have like quizzes which would help with grading…I think because so much is on the tests (Marie, cogenerative dialogue session, October 22, 2017)

Additionally, participants raised concerns related to the use of WebAssign, a digital assessment tool used in the chemistry course. While WebAssign offers significant advantages for assessments including automatic grading of assignments, release of exams, and randomization of questions, participants did not feel that it offered an accurate assessment of their chemistry knowledge. Marie explained,

> "I mean I get that she doesn't want to grade it by hand like 300 people but partial credit should definitely be given especially on big math problems and you get no partial credit like if you're off 1-0 on WebAssign, it's wrong" (Marie, cogenerative dialogue session, October 22, 2017)

Participants reported that the Chem B course was their first experience taking a chemistry exam in a computer format. All previous assessments in high school had been a traditional paper and pencil format. Marie noted,

> I don't think computer… like science and math should be on tests should be on computers like…It should be graded by hand you should get partial credit definitely (Marie, cogenerative dialogue session, October 22, 2017)

The use of WebAssign created problems for these participants for a number of reasons. First, they described the learning curve that was needed to become familiar with the program including accessing periodic tables, use of drawing programs, and managing the countdown clock display. Formatting issues was another source of concern as participants needed to learn how to enter chemical formulas, subscripts, states of matter, etc. There was a variety in the format of test questions including multiple choice, multiple select, and free response. Opportunities for partial credit were minimal and participants stated that small math errors or formatting issues could have a significant impact on exam performance. Marie elaborated,

> Then WebAssign I don't know what it is about WebAssign sometimes the answers you give are mistake like the right answers but it's the way you put it in stuff like that rounding I guess, significant figures little things but and then also they don't take partial credit which I guess is another reason why it's hard making good grades. (Marie, cogenerative dialogue session, October 22, 2017). Similarly, Rickel explained:
>
> They [WebAssign]are hard. It's a good idea but I don't like how much like you do like the slightest thing wrong the whole question is wrong or something like that so I don't like how it's like. (Rickel, cogenerative dialogue session, October 22, 2017). Also expressing frustration with the WebAssign system, Nicole added:

> I am timed I ended up running out from one question and as soon as I got the answer time was up I was like dang it was a it was a like find the limiting reagent and then how much of the excess is left and I was on the excess part and as soon as I got the answer that my time ran out so I wasn't able to type it in (Nicole, cogenerative dialogue session, December 3, 2017)

Nicole also noted her frustration with test questions that covered content that was not covered on course resources or in class. Marie explained how she was only able to answer these questions because of her use of a supplementary course resource, Science Guyz:

> I just realized that what she's talking about the ones with the pictures we didn't go over those in class but in Science Guyz they had like that exact type of question so I already knew how to do it but I realize that we didn't go over those type of those types in class. (Marie, cogenerative dialogue session, December 3, 2017)

The quality of assessments is a critical component to the teaching and learning process. Participants communicated frustration that grades on assessments did not accurately reflect their knowledge of the chemistry content. Additionally, participants who performed poorly on one or more assessments early in the course were often not able to improve their course average because of the grading structure. According to participants in this study, the use of the flipped classroom model coupled with the emphasis on exam performance created a greater need for high quality course resources and support systems.

Course Resources

Course resources was another problem area for students enrolled in the Chem B course. Marie cited inconsistency between the way content was presented and difficulty level of the questions presented across course resources including Cengage Mindtap, WebAssign, and in-class clicker questions:

> Each way you learn is different like the book has different types of questions and in class and then WebAssign is different than in class so it's like you have to know three different types of ways they ask questions (Marie, cogenerative dialogue session, October 22, 2017)

While multiple perspectives may actually prove beneficial to learning chemistry content, the participants in this study did not have a support structure when they needed assistance with learning concepts. While office hours and tutorial were the most likely sources for course support, students found these options to be problematic. Instructor office hours were only offered a few hours each week. It was common for participants to have schedule conflicts with other classes or commitments. Also, these hours were shared across many students decreasing the likelihood of getting individual questions answered. Nicole explained,

> I wish there was more time for office hours. (Nicole, cogenerative dialogue session, October 22, 2017)
>
> He has them only Tuesday and Wednesday but I can't make it Wednesday well if I can make it Wednesday I only stayed maybe 15 minutes because it starts from 3:30 and it ends at 4:45 but I have English at 4:40 so I can stay for like 30 minutes but then I have to leave cause you know I don't know how the buses are running that day. (Nicole, cogenerative dialogue session, October 22, 2017)
>
> The exam is next week there's probably be packed but usually like if I went last well I did go last week there was only three, four of us but when it's test, test week or the week before it's packed and I can barely get my question asked because there's so many people

> you know they're trying prepare for the exam. (Nicole, cogenerative dialogue session, October 22, 2017)

Rickel explained her practice of reaching out to her professor using electronic communication, but recognized this was not always a convenient method for addressing complex chemistry content:

> My professor helped a lot when I didn't like even when I didn't have time to go to her office hours I would shoot her a quick email and she would try to explain my concepts so that I understand like the general idea behind it and then try to figure out on my own. (Rickel, cogenerative dialogue session)

There is a substantial number of free tutorial resources available through the chemistry department, the division of academic enhancement, and other support organizations on campus. Nevertheless, Nicole explained that she rarely used the tutorial services because there was a significant variation in the quality of tutors and many were not skilled at teaching and/or explaining the content to undergraduate students:

> Tutoring…when I go for help at Milledge or somewhere and I ask for help sometimes they don't know how to tackle the problem until I press submit and it shows you know like on Mindtap and it shows you know how to solve it but I don't want to look at you know to show me how to solve it because then I'll know how to solve it I want to be able to tell me okay start here start there but they never really do that they just say okay all right so you're finding that blah blah blah they look at your work but they're they're not actually trying I don't think they try to help or they solve it for you and it's like okay I get it but can you walk me through it like tutoring office hours he walks me through it but

> there's you know we have an hour and there's other people in those office hours. (Nicole, cogenerative dialogue session, October 22, 2017)

Another concern was the lack of coordination between campus resources. There were tutorial and review sessions available through a number of organizations across campus that were not closely affiliated or aligned with the course. Students were not always knowledgeable about these resources including the availability, hours, etc. Also, the organizers were not always directly involved with the course so again there was a great deal of variation in the quality and specific knowledge about the course. Marie noted,

> There could be like review sessions I know they do like a review in Milledge or something before each test but again that's not teachers teaching it like if they had a review session with the actual teachers in their teaching you like I'm going over this for the test I think that would make a big difference (Marie, cogenerative dialogue session, October 22, 2017). Nicole expressed similar sentiments:

> It was some lady, I mean she I think she's a graduate student I don't even know who she is she said she got her degree in chemistry but she I don't know what exactly she does at the university but she's not a teacher she's maybe still in school or she's a TA I don't know (Nicole, cogenerative dialogue session, October 22, 2017)

While there was a number of free resources available on campus, there were other fee-based services and private tutors available. Marie shared the cost and resources available through Science Guyz:

> Like so totally the whole thing it's like you get a packet for each chapter and goes through each type of question I gives you like it teaches well I'm gonna say it lectures it to you but it gets you the overview formulas and then it gives you problems and he works an out

> on there and then gets you time to do some on your own. And then you get a review before each test which are like three hours long but they do help a lot. And then you get a mock test and the answers are online for that. And then it also each week they upload the answers to the progress checks like the week after and then they have tutoring like you can come in there on office hours for $250 but you can also if you just want to like buy one chapter, you can buy it buy one test review or you can buy like that. (Marie, cogenerative dialogue session, October 22, 2017)

Additionally, Marie explained that while she found the resource to be helpful, it favored students who had transportation available to visit the Science Guyz center:

> I usually just go in and do the test reviews and the packets and you just sit at a computer and it he's on the computer and then the reviews he does in person but I think it's made a big like the way Science Guyz teaches it like it's information to you is much easier than like I guess going to class and just getting questions thrown at you (Marie, cogenerative dialogue session, October 22, 2017)

Instructional methods, assessments, and course resources all played a role in shaping the experiences of these African American female undergraduate students' freshman chemistry course. According to Seymour (2001), concern has emerged that "the undergraduate experience might be contributing to failure to attract or retain able students, and that patterns of losses might be (unwittingly) engineered rather than reflecting "natural" wastage" (p. 82). Although, the culture and environment of the course was not raised as a primary issue, it indirectly influenced the students' experience in the course. While class size was not discussed as a primary concern, participants did believe it contributed to the environment of the course. Class sizes were large with no teaching assistant support. Course resources were poorly organized and not clearly communicated to chemistry students. Participants communicated a feeling that there was a "weed out" culture that was indifferent to student attrition.

Possible Solutions

This research investigation sought not to just simply identify areas of concern related to the freshman chemistry course, but to also brainstorm possible solutions to improve the student experience and academic outcomes for the course. Potential solutions identified by researchers included: a) the addition of recitation sessions; b) better TA training/development; and c) a robust chemistry resource center.

Recitation Sessions

Recitation sessions were frequently discussed as a solution to issues associated with the freshman chemistry course. Marie discussed how this structure was used successfully in other courses on campus with large professor to student ratios to leverage teaching assistant support and increase the opportunities to seek assistance. She explained,

> I know in my history class we have an outbreak session like you go to lecture twice a week and it's the same size as Chem but she actually lectures I mean its history but she actually lectures and then there's a breakout class and there's like 20 people in there I don't really like my way and then I think that would actually help a lot." (Marie, cogenerative dialogue session, October 22, 2017)

Marie added that the whole group time could be used for lectures while moving the clicker questions to the recitation period:

> I feel like if they lectured in the big classes and then you came and did the questions in the smaller class and … (Marie, cogenerative dialogue session, October 22, 2017)

Participants discussed how recitation sessions could work to mitigate critical issues in the course associated not only with instructional methods, but also assessments and course resources. According to participants in this study, recitation sessions could provide an opportunity for students to seek more personalized assistance, essentially more office hours. Teaching assistants could offer different perspectives on the chemistry content and approaches to solving chemistry problems. These sessions could also create an opportunity to offer regular quizzes or assessments outside of the current digital tools with grading managed by the teaching assistant.

TA Training/Development

Participants expressed a belief that teaching assistants (TAs) for the freshman chemistry course were an underutilized resource in the course. TAs with proper training and development could make a significant impact in the course delivery and academic experience (outcome). They discussed the significance of TAs not attending the course lectures. Participants felt that a TA presence would be beneficial to assist with the volume of questions, and could offer varying approaches to solving chemistry problems. Rickel explained,

> I wish there were like TAs also in our classes like to help us because there's only one Gilbert like she can't be like everywhere and there's usually a lot of questions (Rickel, cogenerative dialogue session, October 22, 2017)
>
> And also having TAs would give you like different like perspectives on how to solve the problem I just know her perspective, so I mean it's a small thing, but it would be helpful. (Rickel, cogenerative dialogue session, October 22, 2017)

Participants emphasized the great deal of variation in the laboratory experience that existed as a consequence of the assigned TA. Some participants described TAs who did not offer assistance with laboratory experiments or explaining concepts. Marie explained,

> Yeah my lab TA is not very helpful mmm but I mean it's pretty easy so you don't really need much help but like when you do ask her questions she's kind of like ??. (Marie, cogenerative dialogue session, November 12, 2017)

While others, such as Rickel, described TAs who were very helpful and increased the understanding of the chemistry laboratory and lecture content:

> Oh my TA is…he's funny um and he he helps a lot um he knows he knows what he's like teaching per se so like before we start the lab he'll like go through and explain concepts that we may not understand which I really like and I realize that a lot of people don't have TAs like that and also yeah he know he knows like if there's a confusing part in the lab he'll like go through that part before he just sends us off so like he really really does help us throughout (Rickel, 11/12/17). Nicole expressed similar feelings:
>
> I like my TA cuz he explains everything before we start so I know what you know everybody knows what we're doing but I one of my friends her TA doesn't say anything he just says okay start and they're lost and they have to look up stuff and ask other groups for help he literally doesn't say anything so I'm glad that my TA yeah we're stuck and trying to do a calculation or something you ask him and he gives us a hint or say you use this formula that's on the board and you do use stoichiometry and blah blah you'll get the answer and we're like okay thank you. (Nicole, cogenerative dialogue session, November 12, 2017). Rickel elaborated further, noting:
>
> I was on the test and I didn't understand it on the test and after this lab he explained it kind of and I realized what I did wrong so my TA actually helps with like the content or whatever (Rickel, cogenerative dialogue session, November 12, 2017).

> He really knows how to explain the concepts in chemistry and then he'll give us like I like how he just makes up practice problems on the fly even if it's in lab and we just don't understand what's going on he'll just make up like two plus whatever whatever and it will help us understand the procedure better and understand about the concept better. (Rickel, cogenerative dialogue session, November 12, 2017)

Teaching assistants are usually required to hold weekly office hours, but these office hours are infrequently attended by students in the course. According to participants in this study, if the TAs were to receive better pedagogical training and become more involved with the lecture side of the course, students would be more likely to seek assistance. It appears, from participants' comments that teaching assistants remain an untapped course resource with the potential to make significant improvements in the areas of instructional methods and assessments.

Chemistry Resource Center

Participants expressed interest in a more robust chemistry resource center to offer specialized resources and support for the chemistry course, including a study skills course and office hours with staff that were more involved in the day to day operations of the chemistry course. Nicole discussed a desire to have staff trained to properly explain and teach complex chemistry concepts and also offer test taking strategies:

> I would like to have that you know the skills class or somewhere to go where they can actually walk you through it's like I said tutoring they don't walk you through it and then office hours is very limited you only have an hour but there's multiple students coming in office hours so I just I need that extra help and to a person to get me to think of the problem in some way and also it'll help me solve it quicker because that's also been our

> problem I ran out of time the thermochemistry test and I didn't answer four questions and then I was too much in my head and I kept overthinking and doing stuff like going back on my answers when I should have just kept it and kept solving but I wasn't confident I guess but if I had that class and somebody who helped me I would have done better on that test. (Nicole, cogenerative dialogue session, November 12, 2017)

And Rickel describes the need for a resource that would help with study skills and supplemental resources to learn chemistry content:

> What I would have is probably like studying tips or like a little study thing that was not mandatory but like you can go and like it'll help you with because um like in the beginning I didn't know how to study for this subject per se and as it progressed it progressed on throughout the semester uh through trial and error I found which studying methods work best for me and how I learn best with chemistry like the Phet simulator and such like that I just found those so that helped. (Rickel, cogenerative dialogue session, November 12, 2017)

Despite the presence of a chemistry learning center, few students are currently reaping the benefits of this course resource. Participants in this study explained their perception that the majority of students were not aware of the multitude of academic support available for the chemistry course. They asserted the belief that only a small percentage of chemistry students regularly visited the learning center or attend tutorial hours. They further expressed a belief that organizations across campus rarely communicated with each other and were not involved in daily instruction or course decisions. Participants noted that review sessions were poorly advertised and facilitated by staff members who were not familiar to the students enrolled in the course. They emphasized that information related to the course and resources available was commonly spread through word of mouth which created a significant disadvantage for students without an extensive network on campus.

The cogenerative dialogue sessions provided an opportunity for participants to collectively share and reflect on their experiences in the freshman chemistry course. There were some powerful stories from the sessions that emerged as themes that would ultimately shape these students' experiences at University of Georgia and in the freshman chemistry course, as well as their memories of the experience for years to come.

Theme 1: Isolation

One of the most salient themes that emerged from cogenerative dialogue sessions about the experiences of African American females in the freshman chemistry course at a predominantly White institution was feelings of isolation. Students describe the phenomenon of "preformed" or "instant" friendships, where students develop study groups in the course to assist each other with concepts and problems. These groups serve to isolate many students early on in the course. Rickel and Nicole described their experience with this isolation from the very first days in the course:

> Well for me my class is full of like preformed friendships so they're already helping each other out. Do you need help with this problem? And I'm just like uh I'm in the corner just all to myself I have my friend from like high school but she just withdrew so I don't have anyone anymore but it's like they help each other out in their own little groups and so me not not really having that type of aid it's different. (Rickel, cogenerative dialogue session, October 22, 2017)
>
> Ah yeah there's just a lot of the very first day there are already groups in people were already you know helping each other solve the problems and I was all by myself and yeah

> there's this one girl but we're not really friends we just said did you get the right and you get this answer yeah okay good and that's it same with the other guy like did you get this yeah so that's basically yet but the other people are actually talking they're explaining it and all this stuff and then I heard about test banks so it's like though those group of people throughout the classroom might have test banks so they're studying over the tests where I'm studying by myself I don't have you know anything to look over to help me with exams I just have me and then the resources that they give me WebAssign, Mindtap all that stuff. (Nicole, cogenerative dialogue session, October 22, 2017)

When asked why this phenomenon existed in the freshman chemistry class at University of Georgia, Marie shared her observation that "everyone from my high school comes here". Participants discussed how these clusters of friends from high schools around the metro area served to exclude students who were not part of such cohorts, especially students of color. Marie explained that most of the African American students that she knew from high school or socialized with on campus were not science majors or required to take the Chem B course:

> We have a little group chat for like buga black uga like health professions like people who are in science majors it's only like 30 people in the group chat and it's like if you don't have class with them there's no point in you can't really do progress checks together if you don't have class with someone and I know like in my chem class probably like three people and it's a big class so you guys probably should know more but I guess my friends I guess people I like hang out with mostly aren't chem majors like are not science majors. (Marie, cogenerative dialogue session, October 22, 2017)

Personality may also play a role in this isolation. Nicole explained, "I think it's even harder for me because I'm more of an introvert" and Marie echoed this sentiment saying, "I've always just liked working by myself". This trait of introversion may make it harder for these students to actively seek opportunities to create or join study groups. Nicole and Marie both discussed the challenges or disadvantages associated with working with other students:

> I've never been like a group project person anything like that I always like doing it myself and I found that the same thing with time like it's so much easier just to open the book and do it in my room instead of going across campus and bringing all your stuff to meet other people that's really it I've just always been an independent studier or I've never really studied with other people regardless of what class it was. (Marie, cogenerative dialogue session, November 12, 2017)

> Honestly sometimes it's helpful when you get stuck on a problem but with me my personality I'm an introvert and I like to do things by myself I don't know why but then I also want to seek help when I need it so sometimes when I'm if we're doing a study group and I'm working on it by myself and I'm getting in they might they might ask me a problem that's simple for me and it's like oh you just stopped me from doing my work but I'll help you I don't know I don't know why (Nicole, cogenerative dialogue session, November 12, 2017)

Rickel, who described herself as more of an extrovert, preferred to work with others but found it difficult to develop these relationships on campus:

> It's not…I think I'm a very extroverted person so I try to talk to anybody anything but like I don't know it's just weird yeah I don't know how to put it like it's we don't have I don't know they just could be a color thing it could be like I know her better or whatever I don't know but it's just it doesn't happen per se as easily as it would be with their other friends (Rickel, cogenerative dialogue session, October 22, 2017)

Rickel recalled how the smaller summer class made it easier to form study groups. She noted that during the fall semester, students experience more academic stress and pressure to manage time:

> Oh for me over summer our chem class I think it was time honestly because over the summer we had a whole like big study group of probably 15 people and we would meet in a study room and like right on the whiteboards and have races who can do it quicker and stuff like it was really fun but now I don't think people have time for that I think everybody's so stressed out and even the people in chemistry I feel like they would just prefer to sit down and get the concepts that they themselves don’t know because since it's such a big class everywhere everybody's had a different place so if somebody thinks one problems hard the other person might think it's a burden on them to study with them and they don't understand what they understand so for me I would like to work in bigger groups cause like for me I'm more extroverted so I would like to help teach somebody and that would make me better at that concept but I it's probably time something like that I don't know. (Rickel, cogenerative dialogue session, November 12, 2017)

Rickel was the only participant who regularly studied with other chemistry students. She described her involvement in study groups and how her participation had improved her understanding of the chemistry content:

> Yeah I actually studied with a group this time and that was with Larry and like two other people if that helps I think that helped a lot because I was I was asking some questions but more I was teaching other people and these two other people I don't really know that well so I really went in depth and that helped me understand the concept better for myself. (Rickel, cogenerative dialogue session, December 3, 2017)

Rickel offered advice to other students of color emphasizing that they should not be apprehensive about developing relationships with other students in the course despite the presence of these existing friendships:

> I would say for somebody who is any type of like minority to not be like intimidated by like the groups of friends already formed in the class and so you don't really want to ask them for help or whatever cause that's what I was like struggling with in the beginning when I really needed help but I they were already friends with each other now I was just sitting there like that and then. (Rickel, cogenerative dialogue session, 1/7/18)

The presence of these "instant" friendships and feelings of isolation were a significant area of concern given the issues identified with the instructional methods, assessments, and course resources. A peer network could potentially offer significant benefits in improving the student experience and performance in the course. Additionally, isolation could likely increase in advanced science and math courses where there are often fewer people and less resources.

Theme 2: Relationships with Faculty

Educational research has emphasized the importance of relationships between teachers and students in academic settings. Relationships played a significant role in the participants' feelings about the course. Participants who described positive relationships with their professors had better academic outcomes in the course. When asked 20 years from now what they would tell someone or what they would remember about chemistry, Nicole whose final grade in the course was a B+ responded with a simple statement, "My professor." Chemistry professors are often associated with the lack of impersonal relationships or indifference to teaching, but Nicole shared how visits to her professor's office hours changed how she viewed chemistry because of the assistance he offered and his genuine level of concern about her success in the course. She explained,

> I love Mr. Young. I do it was nice talking to him not just about chemistry like football games I'd say hey you going to the football game or something after office hours he's like no we're staying home we're cooking he said sloppy joes or some like that yeah I'm craving wings it was the football game was it it was a huge it was the Florida Gators one. Mr. Young after like going to his office hours it changed how I viewed chemistry because he helped me a lot I well I still didn't like chemistry but he was always there to help me so it was nice talking to him. He is very genuine and he learned in the office hours he was always trying to learn our names and he eventually did maybe like third time and then he was funny like he called his tests celebrations of knowledge that was cute and he was trying to get us different way give us different ways to think of chemistry and tests and he was like what do you say just show me what you know the celebration of knowledge you've done it already he was very encouraging I like him.

Additionally, Rickel, who earned an A- in the course emphasized the relationship that she established with her professor early in the course:

> I don't know…for me um I because I already saw like the first day that they were like groups or whatever and they were helping each other out I just wanted to have good relationship with the teacher so with Gilbert and I she already knows my name like she knows what I want to be in the future and stuff so like it's it's like they have their own a but I'm trying to get like close with the teacher since I don't have that like support and then she's she's a nice woman and she'll help me if I come to her with like a problem or

> whatever so I thought it was important for me to establish that connection with her (Rickel, cogenerative dialogue session, October 22, 2017)

This positive relationship was a sharp contrast to the response offered by Marie who earned a final grade of a C in the course. When asked about her relationship with the professor, she commented:

> I really don't have any connection with her have a nice really close with other teachers but just haven't been able to make that connection with her and I probably should make more of effort to go to office hours office hours and things but it's like when in class she confuses me about explaining things so I was like I go to office hours just kind of confuse me more. (Marie, 10/22/17)

Marie was also the only student who shared a negative experience as being her most notable memory about the chemistry course:

> I would say my teacher cause I really didn't like the way she taught at all and she would get mad at us for everything like leaving class early even if you were done with the assignments or for having our phones out stuff like that even if you had finished it so she would just get mad at us really easily and I like with the clicker questions I still don't like them I hate the idea of a flipped classroom I just think that's a bad a way to teach.

Although it can be very difficult in large, introductory courses for students to establish professional relationship with course instructors, these accounts should serve to remind chemistry faculty of the importance of developing relationships with undergraduate students.

Theme 3: Role of Social Networks and Support Systems

Nicole recalled an early experience with her advisor during preregistration for her fall courses. She described her frustration with a discussion of her diagnostic test results during an advisory experience that served to discourage her pursuit of her STEM major. Ultimately, it was the support of her parents and previous academic experiences that provided a degree of confidence in her ability to manage her coursework:

> I'm not really a great test taker but I know my stuff and I'm hard-working so my mom was like we know how you how you what kind of student you are you're hard-working my dad was saying the same thing and when I left after talking to her I got overwhelmed and when I get overwhelmed or frustrated I'm about to cry in the back of my throat hurts so that's what was happening and I was like why am I overwhelmed but she was just saying how based on my scores I was one point away from being able to go to Calculus 1 so she was talking like that so I have to be in precalculus and then she was saying based on chemistry I got a low score so she was like take 1210 well not take 1210 but I can do whatever I want but I was in that quartile where it's it's on the lower side so she's talking about I don't know how well you'll perform or something in chemistry … and she was talking about how precalculus and chemistry are hard classes that most people like fail or something like that so she was discouraging me but I was telling her no I'm gonna do it like I felt like I was kind of I was being strong cause I knew me but at the same time the way she was saying it in how she was you know saying oh this is hard blah blah blah and I just felt not down but… (Nicole, cogenerative dialogue session, January 7, 2018)

Nicole's story served as a reminder of the important role that advisors sometimes play to encourage or discourage the pursuit of a STEM pathway, especially for females and students of color who are already underrepresented in this field. Additionally, Nicole's support system outside of the university was able to play a pivotal role in moving her forward to pursue her academic goals.

Relationships with parents served as an important support system during the course for some of the participants. Nicole described “a very close relationship” with her parents and how she felt comfortable with routinely sharing her chemistry exam scores with her parents. Nicole explained that her parents were very supportive of her transition to college and helped her manage the academic demands that she placed on herself:

> They understand that college is hard so right off the bat they're like Bs are good and then they said if you get a C it's okay just balance it out with Bs and then the classes that you get A or the classes that you can get an A get an A in and I'm like okay but see I didn't understand that concept and so I started with the bad grades in chemistry and then I did bad on one of my just one of my math quizzes I was like um now it's been good so far but they you know I tell them my grade they're like it's okay so what was overall you know letter score I was like oh that's a C- minus they're like a C- minus is good I'm like why are you guys like so good job I don't like Cs, but.. (Nicole, cogenerative dialogue session, November 12, 2017)

Participants also expressed anxiety about the future and their ability to be competitive when applying to professional programs. Rickel communicated how her mother was always a source of encouragement in these times:

> Like the other night I was in class what class were we in I think was African history I'm taking and I did bad on the test so I was looking through like med school requirements like with average GPA like I was stressing myself out cause I thought I'm gonna do bad I don't know if I'm gonna get into med school or whatever but my mom she's an educator so I texted her and I was like I'm stressing out and she was like don't worry about it yada

> yada so sometimes I'm stressed out but it’s fine we’ll survive we’ll survive it’s fine. (Rickel, cogenerative dialogue session, December 3, 2017)

Marie likewise described a close relationship with her parents. She had discussed with them the possibility of transferring to another institution at the end of the school year, but did not feel comfortable sharing details about her academic performance with her parents. When asked whether she shared exam grades with her parents Marie explained, “I don't ever tell my parents because they're so used to me getting A's I'm so just like I can't even no.”

Of the three participants, Rickel had the most extensive support network on campus. When asked to share a memorable or defining experience about her first semester in chemistry, Rickel reflected on an impromptu study group that formed in the lobby of her dormitory:

> I think it was a Saturday and I was down I live in Ohouse and we have like a lobby and I was downstairs working on our Mindtaps cause they’re due on Sundays and this one was like just so long and just frustrating so I see Lary walk through and Larry has his bookbag and he said are you doing the Mindtap and I say yeah you want to do it with me so he sat down and then like three people I do not know just randomly walk in and we all are sitting down asking each other questions I think that was the most fun because I learned the most that's I think that night was when I realized how helpful group work could be because what she didn't know I knew and what I didn't know she knew so it was just all like a circle of fun and it was just created like out of nobody planned it was fun.

Rickel’s support network was more extensive than the other participants. This could likely be attributed to her extroversion and involvement in the pre-freshman summer experience and Chem 1210 course. This network served to provide her with additional support and course resources. She explained,

> I know for the final exam we had they recommended to buy that book I forgot what it's called but that seems to explain things a lot easier so I feel prepared for the final exam. I don't know how much it costs. My friend gave it to me for free. (Rickel, cogenerative dialogue session, December 3, 2017)
>
> And then honestly my friends in Ochem helped a lot because um yeah like they took it already and they know how the class works so me talking to them kind of gives them a refresher on general chemistry which they said it helps them in Ochem and then they help me when I'm struggling in chem I asked my friend about don't it was a bond order it was specifically for O_3 I didn't understand why it was 1.5 and he helped me through that …so yeah (Rickel, cogenerative dialogue session, November 12, 2017)

Rickel even discussed her Chem 1210 experience with the TA and highlighted the supplemental resources that she received and her continued use of these resources in Chem 1211:

> She really caters to everyone's different learning strategies per se like she had online simulators like something simulating and um like she also had like basic worksheets sometimes she'd have competitions and stuff like just things they like really interact with the students and it was a small class there were only ten people in my class but so like she knew people personally and that kind of helped us when we had a problem or whatever and so all her little things like she gave us websites that we could use when we don't understand concepts or whatever they'll make a simulator that help but go through the motions and everything that helps me because it's like visual um and so when in 1211 when I don't understand something like the models we're doing right VSPER now yes I go on that website. (Rickel, cogenerative dialogue session, October 22, 2017)

Social networks and support systems provided an additional level of support in the course. In addition to personal networks, participants described the benefits they received from involvement in summer bridge programs and campus organizations such as National Society of Black Engineers (NSBE), Louis Stokes Alliances for Minority Participation (LSAMP), and Minority Student Science Association (MSSA).

Context for Case Two

Case Two was conducted during the spring semester at the University of Georgia. This is a notable difference from the first case because students already had one academic semester to adjust to their new environment and the academic demands of college. Data collection began in February 2018 and concluded in June 2018. It consisted of two co-generative dialogue sessions, individual interviews, and a photo-elicitation exercise. The co-generative dialogue sessions and individual interviews took place on Monday evenings in the Science Learning Center (SLC). The research participants included 2 African American female undergraduate students enrolled in Chem B; Jordan and Myrtle. The participants had nontraditional housing arrangements for first year students. Jordan still lived at home with her parents in Oconee County and Myrtle lived on campus in apartment-style graduate housing with one other freshman student. Myrtle was pursuing a pre-medicine professional program while Jordan had declared a chemistry major. Both Jordan and Myrtle were enrolled in a CHEM B lab section taught by the primary researcher. Jordan and Myrtle attended the same evening section of Chem B taught by Professor Gilbert.

During the data collection, several similarities were noted among the research participants. First, Jordan and Myrtle had experienced a great deal of difficulty in the freshman chemistry course earning scores of 35 and 45, respectively out of 100 points on the first exam.

Based on these failing scores, both participants had given consideration to the Chem D "dropback" option, as well as course withdrawal. Both students discussed that withdrawing from the course would have caused their enrollment status to drop from full time to part-time which could potentially lead to future problems with financial aid and/or housing eligibility. Jordan added that she wanted to stay in the class because she refused to "give up" or allow the course to "beat" her. Jordan and Myrtle both expressed the belief that they were "good at science" having previously experienced success in the areas of science and math at the high school level. Despite similarities, in agreement with Black Feminist Thought, rich differences among these participants offered a greater context to truly make meaning behind the experiences of Black women. One notable difference was in their educational backgrounds. Jordan was educated in a large, public high school in an affluent community with a notable lack of diversity in the student body. Myrtle attended a small, charter high school in an urban setting with a 99% total minority enrollment. Additional differences included family background, personality, and study habits.

In addition to these contextual factors, there were also three methodological differences noted between case one and case two. First, while an inductive process was used to inform both research cases, emerging themes from case one were sometimes used to develop content or shared to benefit participants in case two. For example, isolation was identified as a key theme in case one so participants in case two were strongly encouraged from the beginning of the study to participate in study groups, attend tutorial, and develop relationships with their professors. Additionally, both participants were enrolled in a Chem B lab section taught by the primary researcher. Concerns related to chemistry laboratory, specifically the role of teaching assistants were not discussed in co-generative dialogue sessions for case two to ensure that all participants were comfortable and able to offer candid feedback on the course. Another important difference relates to the structure of the last session between the two cases. Rickel, Nicole, and Marie all participated in a final co-generative dialogue session during the first week of January and were able to collectively reflect on their experiences in the freshman chemistry course. Myrtle opted out of the last co-generative dialogue session during the first week of June, so Jordan was able to individually reflect on her experiences in the freshman chemistry course. While Jordan was observed to be very open throughout the research process, it is possible that this private setting allowed her to be even more candid about her experiences, specifically her previous racial experiences and her identity as an African American female in a STEM field through the photo-elicitation exercise.

Critical Issues

One of the primary goals of this research investigation was to identify critical issues raised by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution. The first case was characterized by academic factors that were explicitly communicated including: a) instructional methods; b) assessments; and c) course resources, and the second case was able to shed additional light on these same critical issues.

Instructional Methods

Instructional methods was once again a significant area of concern for students during the co-generative dialogue sessions. Participants found the "flipped" classroom model to be problematic, expressing a preference for traditional lecture methods as a better way to learn the chemistry content and grasp more complex concepts. Jordan described the contrast between her experience in high school chemistry and the freshman chemistry course:

> She was very hands-on that's why that's why I think I'm struggling a little bit is because I'm used to you know like teachers being up on the board and you know being like this this and then looking at us and be like okay you don't understand it so let me go over it again but here it's just like it's real fast paced and I don't I don't learn well just being read to (Jordan, cogenerative dialogue session, March 19, 2018)

Jordan explained that the high school course did not prepare her for the instructional methods that she experienced in college:

> I think during class like actually like drawing it out you know don't just put like a question up there and say do it cause because I mean in high school you know they prepared us to take notes they were like you need to learn how to take your own notes cause that's all you're gonna be doing in college so I was fully prepared to take notes you know but then when it wasn't that I was like well how do I study and learn this stuff you know (Jordan, individual interview, June 6, 2018)

Jordan also discussed the experience of retaking the freshman chemistry course at another nearby institution. She found the traditional lecture method to be more beneficial with respect to content that she had struggled with in the previous course:

> So that’s why I’m taking it now at North Georgia and I'm feeling pretty confident about it there because he I mean the way they teach it they like go on board and he like actually goes through notes and stuff so it's like okay that's how you really do that you know that is like kind of refresher because now I can see actually how actually do I knew something about it you know way I think is different from that was different from the class here because you know it was just clicker questions. (Jordan, individual interview, June 6, 2018)

Myrtle complained that the lecture did not provide a clear explanation of concepts so she frequently relied on supplemental resources, such Bozeman Science and Clutch Prep, when studying for the course:

> They are [helpful] because he physically will draw things out because I was having a tough time with the recent chapter that we were on the electron configurations and it was moving too fast so like he drew out like how like all the periodic table like how they flow and how go so that helped a lot (Myrtle, cogenerative dialogue session, March 19, 2018)

Both Myrtle and Jordan expressed that the professor was not able to clearly explain concepts, did not offer answers that were "in-depth" enough, and was not able to gauge when students did not understand material. The following comments highlight the participants' concerns related to seeking help during lecture:

> I would like I don't know more visual representation like when we're doing like clicker questions and stuff like sometimes just like saying you know what the answer is and just you know it's not gonna like okay that's the answer but could you do a little more to show me why it's the answer and I mean she Dr. Gilbert she does like try to explain them like she does try to explain them but it's not like in-depth enough for me (Myrtle, cogenerative dialogue session, March 19, 2018)
>
> She explains it in the most basically like a generic way possible and like expects me to get it or it repeats the same generic thing when I ask her again like could you explain it in a different way (Myrtle, cogenerative dialogue session, March, 19, 2018)
>
> When she does something you know like draw something and like people like will just like nod at or like they do get it but they don't and she'll just be like okay (Jordan, cogenerative dialogue session, April 9, 2018)

Myrtle was very concerned about potential disparities created based on differences in classes, lecturers, and content coverage. Her professor shared on more than one occasion that she was not involved in the development of the course assessments, so Myrtle expressed concern that different course instructors may not be on the "same accord" as it relates to what students should know and what content would be emphasized during the hourly exams. Myrtle expressed this sentiment as follows:

> That's the thing like he comes up with all the things, but it seems like they're not on the same accord, it seems like they are not on the same accord in terms of what should be taught and what should be focused on (Myrtle, cogenerative dialogue session, April 9, 2018)
>
> I guess it would be again with the testing because our my professor like she tells us like that she doesn't make the our actual test so it's kind of I want I would like for both of them to be on the same accord of what's going to show up and like what kind of like questions will show up so that they can prepare both of their classes (Myrtle, cogenerative dialogue session, March 19, 2018)

Assessments

Concerns related to assessments were raised once again during the co-generative dialogue sessions. Myrtle and Jordan discussed problems associated with the online testing program, WebAssign. Specifically, there were concerns related to the lack of partial credit given for incorrect questions. Myrtle described a, "system so sensitive they're like one small mistake can mess you up." Myrtle found the number of errors on the WebAssign tests to be problematic:

> That is like the biggest I feel like WebAssign is fine like the homework and the quizzes are fine on there and the Mindtap is fine but I feel like the online quizzes are just they're

> very problematic and also even when they make the answers for it even when previous like every single test we've had on the online one there's always been errors with the keys (Myrtle, cogenerative dialogue session, March 19, 2018)

Even though the chemistry department would make adjustments to the students' scores, Myrtle described how the errors created an additional level of test anxiety. It was her belief that these experiences had a negative impact on her exam performance:

> They have made adjustments to the scores but I still they're always the ones that still select all apply and that's the ones that always throw me off like because I know the right answer but I don't see it so it just makes me even more paranoid and nervous like maybe I'm not studying right or maybe I'm not remembering something right (Myrtle, cogenerative dialogue session, March 19, 2018)

Course Resources

The course resources were again described as a source of frustration by participants. There was a general sense that the Cengage Mindtap offered a more simplistic representation of the content than the materials presented in lecture and on WebAssign. Myrtle described this conflict between studying outside of class with MindTap and the difficulty level of materials used in class:

> The Mindtap is before [lecture] but for Mindtap, I feel like Mindtap for me gives like a general sense of it but for our lecture it's like more in-depth and I think she expects us to understand it more in-depth even though Mindtap is like a general thing that we have like it's not specific on what she's asking and her questions (Myrtle, cogenerative dialogue session, March 19, 2018)

In the following example, Myrtle complained about a test question and her feelings that the content was not clearly covered during lecture:

> It was like our slides and our slides are formatted very poorly like was all like the questions like I don't even think like it was probably like a question like a true or false question that was geared towards this subject there like probably somewhat subliminally answered my question but it wasn't like a concrete this is that and that is that like in our slides it's never that it's a bunch of questions like practice questions like I want a slide that has like actual material on it (Myrtle, cogenerative dialogue session, April 9, 2018)

Additionally, Myrtle discussed challenges associated with WebAssign. She described how there are detailed solutions available for some questions, but only an answer key for other problems on progress checks:

> It'll be more of the like critical thinking ones where you have to like plug everything together that I didn't get right or I did and I didn't understand how to do it but when it's time for the homework's over and they have submit the answer key it's just there's no like in-depth explanation of how to do it or how to come to that point of doing it so I feel like that's kind of that kind of is a crutch for people for a lot even for me (Myrtle, cogenerative dialogue session, March 19, 2018)

In the absence of detailed solutions, students may sometimes develop misconceptions or false understanding of how to correctly solve problems. The likelihood of this may be increased by the number of students who do not regularly attend office hours held by a professor or teaching assistant. Jordan described her confusion related to the tutorial hours offered by the chemistry learning center:

> I talked to a guy because I didn't know where the tutoring and stuff was and so one day when I was leaving lab I like see a sign on the door and like this man sitting in there I'm like do you know this about this and I couldn't do it right then cause I had another class to go to and so I still don't know am I supposed to sign up online for that or do I just walk in? (Jordan, cogenerative dialogue session, March 19, 2018)

Participants were often not aware of the free resources available through the Chemistry Learning Center and the Division of Academic Enhancement. When we discussed the exam review sessions, participants described confusion related to the date, time, and location for these sessions:

> I haven't really heard about the review sessions (Jordan, cogenerative dialogue session, March 19, 2018)
>
> I hear about them but they don't have them labeled properly I don't think they do they have them labeled properly? (Myrtle, cogenerative dialogue session, March 19, 2018)
>
> I don't at all cause there's a review session that happened before that was in our regular lecture hall but then like I didn't know if it was the right one and then I walked in afterwards when it was over and it had like an entire different chemistry on there so. Cause I usually walk in I really like I'm always like 30 like 45 minutes early for class anyway so I was just sit in the back of it and it wasn't the right one (Myrtle, cogenerative dialogue session, March 19, 2018)

There was significant overlap between the critical issues presented in the first and second case, but the context and poor academic outcomes in the second case introduced some additional concerns related to the course. Myrtle and Jordan were both experiencing a greater level of academic difficulty in the course, as they were both failing the course when data collection began. Myrtle's final grade in the course was a C- and Jordan's final grade was a D. Based on these academic outcomes, both participants will be required to retake the course in order to continue in their respective courses of study. For these reasons, this second case may have highlighted some key non-academic factors that were indirectly transmitted by the participants. These critical issues can be classified into three categories: a) isolation; b) lack of advisement; and c) detrimental effect on other coursework.

Isolation

While isolation emerged as a key theme in the first case analysis, it was identified as a critical issue in this second case. Participants described a physical and academic isolation that impacted their performance in the chemistry course. It was revealed during the first cogenerative dialogue session that both Myrtle and Jordan's housing arrangements were not typical to traditional incoming freshman. Jordan, who had attended high school in Oconee County, had opted to stay at home and lived with her parents and older brother. She described her struggle to stay motivated in the course and admitted that she often found herself watching TV or engaging in other distracting behaviors. Jordan described one of her goals following the first cogenerative dialogue session as "just removing myself from my house." During her individual interview, Jordan discussed optimism about living on campus during the next semester:

> Next semester, I'm staying on campus and I really do think if I stayed on campus I would've studied better because you know you got like little study rooms like this and you can like gorge yourself you're not going home you know where the distractions are and so I'm gonna study a lot more yeah (Jordan, individual interview, June 6, 2018)

Myrtle's housing situation was not the same as Jordan's, but did create some physical isolation from other students. Myrtle explained that due to renovations of one of the housing dormitories, she had been placed in graduate student housing for her first year. She lived in an apartment that she shared with one other student. The apartment had a private entrance and there were no common areas or shared spaces that are usually found in traditional dorms. Additionally, many of the campus buses did not stop at the housing complex, making it harder to stay on campus until later at night.

When the cogenerative dialogue sessions started, like the participants in the first case, both Myrtle and Jordan shared that they usually studied by themselves. At the closing of the first session, Myrtle and Jordan were encouraged to seek opportunities to study with other students. Jordan and Myrtle began to study together for the chemistry course. Neither participant attended any of the tutorial sessions offered by the professors, teaching assistants, or other academic offices. Of particular concern was the practice of studying in smaller groups with other students who were also experiencing difficulty in the freshman chemistry course. Jordan shared that she studied with another student in the course who seemingly understood the content, but was not able to perform well on the hourly exams. When I asked if the student was doing better than her in the course, Jordan offered this response:

> No, but she's like she can explain it to me and she'll be right but on the test like she doesn't do good either (Jordan, cogenerative dialogue session, March 19, 2018)

During her reflection, when asked if she had anyone to explain content that she didn’t understand to her, Jordan expressed uncertainty in the subject matter expertise of her group members.

> No, because even if I was like studying with my friends you know I still wouldn't be like this is like exact you know so I'd be like this could be wrong cause none of us really know you know (Jordan, individual interview, June 6, 2018)

While Jordan studied with Myrtle and other students enrolled in the course, Myrtle only studied with Jordan. This may or may not have been advantageous to Myrtle because she was performing better in the course than Jordan. Jordan described Myrtle as a "good teacher" who "explained everything like really well" expressing a belief that she "finally got it" referring to the chemistry content. Myrtle opted not to participate in the final interview so I was not able to inquire about the experience from her perspective.

Myrtle was a conscientious student with excellent time management and study skills. She described a system of working in Mindtap, WebAssign, and other resources including videos and websites to learn the chemistry content:

> I if I don't understand something I regroup I would use my outside sources but if I understand it like straight off the back for like Mindtap or the WebAssign homework that I don't like go further out (Myrtle, cogenerative dialogue session, March 19, 2018)

While I expressed concern that Myrtle did not seek assistance in the course, Myrtle was content to study by herself. She did share one negative experience when she reached out to her professor to inquire about a missed question on one of the hourly exams:

> I like I had questions I just legitimately had questions because I want to know why they were wrong like was a hundred percent sure I thought they were right and I emailed her like my list of questions and like I copied and pasted like directly from the test like these questions I'm like this was my answer and I want to know why this was the correct answer and I felt like it was a little snippy with it like she was like da da da da and this and that and that she gave me the answer yes but then she added like a remark at the end saying you should have reviewed our slides more you should have done this like I've already discussed this (Myrtle, cogenerative dialogue session, April 9, 2018)

Myrtle communicated frustration with the tone of the message, but insisted that she was "over it." It was a concern that this one negative experience may have created an additional barrier or deterrent to her reaching out or seeking help in the future. The issue of isolation highlights the need for students like Myrtle and Jordan to have opportunities to interact with faculty and/or staff who were knowledgeable and involved in the freshman chemistry course.

Lack of Advisement

Another critical issue that was very clear from the first cogenerative dialogue session was the need for high quality advisement for students experiencing academic difficulty in the course. As discussed previously, both Myrtle and Jordan had performed poorly on the first hourly exams. They both scored low enough on the exam that they were strong candidates to move from CHEM B to the CHEM D dropback option. Neither participant appeared to have given much consideration to this option. Both participants had also considered course withdrawal. Myrtle had decided to stay in the chemistry course because she did not want her enrollment status to drop from full-time to part-time. She described dropping to only ten credits as a potential "red flag" that could create problems in the future with housing eligibility or financial aid.

The first cogenerative dialogue session was held on Monday, March 19th which was the deadline for course withdrawal. As the session came to a close, I was caught off guard when Jordan asked, "Do you think do I have a chance to get like a C in this class?" I explained that it was not appropriate for me to make a recommendation for course withdrawal. All of the participants engaged in a long discussion about enrollment status, housing eligibility, financial aid, grading structure, and other specifics about the course. Jordan confirmed that she had not discussed dropping the course with her professor or determined how it might impact her financial aid. Jordan stated that she had discussed the chemistry course with her advisor. As the conversation progressed, she continued to ask the primary researcher questions, such as, "So, you don't think I should drop?" and, "Wait, but I have a fighting chance [to earn a C]?" Jordan communicated a great deal of confusion related to her exam scores and potential academic outcomes in the course. Without the expertise of the chemistry faculty, Jordan was asked to share her expectations for the course:

> Uh well I mean I you know I thought they curve grades before until I was kind of hoping for that and I was hoping for the bonus points and I also was like hoping maybe this test I will finally you know get maybe a B or C and I heard a lot of people do good on the final to that standardized (Jordan, cogenerative dialogue session, March 19. 2018)

This pattern would continue throughout the semester and even after the course ended. During her final individual interview, Jordan expressed concern that she had not done well on her ACS final exam, but did not know how or where to view this grade. Once again, Jordan would ask the primary researcher for assistance with this inquiry.

My relationship with the research participants was a great source of stress during both the data collection and analysis process. This relationship continued to evolve back and forth from teaching assistant, researcher, and graduate student to that of an advisor, friend, and maternal figure. Involvement in the discussion about course withdrawal created a very uncomfortable dilemma for the primary researcher. On the one hand, I had strong opinions regarding the students' ability to perform satisfactorily in the course, but on the other hand, I was not knowledgeable about the other potential implications. It is a question that would continue to haunt me over the course of the semester, after I learned about the final grade outcomes, and potentially into the future whenever I reflect on this research investigation. This lack of advisement would also create additional concerns outside of the chemistry course, as I learned about the detrimental impact of the chemistry class on other courses.

Detrimental Effect on Other Coursework

Myrtle and Jordan were both experiencing difficulty in the freshman chemistry course, but were confident that they could balance their coursework. The decision to remain in the chemistry course would have a detrimental impact on their other coursework. Myrtle’s final grade in the course was a C- and Jordan’s final grade was a D. During the cogenerative dialogue sessions, both participants were optimistic about their other courses.

Myrtle was also enrolled in Freshman Chemistry Lab, Intro to Public Speaking, Calculus, and English Composition. She did well in her other courses, but earned a C in Calculus, a significantly lower grade than in precalculus. In this quote Myrtle discussed the “extremely fast” pace of the course:

> It's manageable but it's like I am like thankfully like my load isn't as strenuous as it is but because that's where the majority of my time is going but it seems like sometimes for some weeks like this week they're packing in like an entire chapter into this one week where we only meet twice a week if we met three times a week the class might have been a lot different because they can spread stuff out more and it wouldn't be as like packed and compres.. packed in in the hour and a half that we have hour and 15 minutes (Myrtle, cogenerative dialogue session, March 19, 2018)

Jordan was enrolled in Freshman Chemistry, Freshman Chemistry Lab, Precalculus, First Year Odyssey, and Spanish. Jordan earned a C- in Freshman Chemistry Lab, a C in Spanish, and an F in Precalculus. Jordan lost her HOPE eligibility following the spring semester and enrolled in four summer courses in order to get back on track and improve her academic standing at the university. In this quote, Jordan described how the pressure from the chemistry courses affected her other courses:

> I think there was always pressure to some extent but I think it really affected me like anxiety and stuff with my other classes because like I mean I come to chemistry and I've never know I've never missed a class except for that one time I got flat tire and so I would always like listen listen listen but then I mean I know I could have passed precalculus with probably an A but I didn't give it any time (Jordan, individual interview, June 6, 2018)

Jordan and Myrtle were both able to make significant improvements in their course averages during the spring semester, but the time and effort would not be enough to prevent a negative academic outcome in the chemistry course and a detrimental effect on other coursework. It would appear that based on the grading structure for the course, students who performed poorly early in the course ultimately reach a "point of no return", a point at which it became mathematically impossible to perform well in the course.

Possible Solutions

The first case analysis identified several potential solutions to address the critical issues associated with the freshman chemistry course. While recitation sessions, TA training/development, and a more robust chemistry learning center would offer additional support to students enrolled in the chemistry course, the second case highlights a need for some additional options. As discussed previously, critical issues presented in this case were indirectly communicated during the cogenerative dialogue sessions. As such, these prospective solutions identified by the primary researcher were: a) development of structured study groups; and b) faculty selection.

Development of structured study groups

In the spring of 2018, students in one section of CHEM B were offered the opportunity to enroll in a study group with other students in the course. The study groups met weekly for approximately 3 hours and were led by a student who had recently completed CHEM B, earning a B or higher in the course. Myrtle and Jordan both expressed interest in this opportunity, but unfortunately study groups were not made available to their chemistry sections. The development of structured study groups on a larger scale could be a potential solution to some of the critical issues in the chemistry course. It could reduce some of the isolation experienced by students by ensuring that everyone had the opportunity to participate in a study group. It could also reduce the likelihood of lower-performing students working together and ensure the existence of minimum level of content knowledge across these student-led groups, an issue that Jordan communicated as an area of concern.

Faculty Selection/Lack of Diverse Faculty Members

Faculty selection and the presence of diverse faculty members was another potential solution raised to address the critical issues in the chemistry course. Jordan and Myrtle discussed the importance of faculty who understood the diverse needs of incoming freshman students. In the quote that follows, Myrtle discussed the unique needs of freshman, the success of one specific faculty member and how his communication skills should be a desirable trait in faculty members working with the introductory course:

> This is a freshmen course so that means you finna be dealing with these freshman like I feel like pro- people who teach introductory courses need to be like at another level of

> something I feel like they should be more like in tuned with their emotions because for some people I've met a lot of different people some people have never been outside of their small city and some people like are like from Atlanta like me and I have never experienced something such fast paced or like didn't have like the best school system so we don't understand it completely so I'm like we're coming from all different backgrounds and dynamics so you have to like find a way to like be personable but like try and like all reel us in under one channel of understanding like I feel like this is a very nice school and I feel like they have the resources or have like the the power to like find individuals that are like that like how they describing like how Young is or whatever his name is um they he's kind of like that like he's really good at explaining and he's like personable or whatever he does like but not personable but like he like understands how to teach freshmen classes because it's a freshmen course (Myrtle, cogenerative dialogue session, April 9, 2018)

While HBCUs make up less than three percent of U.S. postsecondary institutions, they demonstrate considerable success in awarding degrees to Black students. When asked to explain the success of HBCUs in graduating African American students with degrees in STEM fields, Jordan and Myrtle attributed it to the presence of faculty with a vested interest in the success of “minority” students. In the following comment, Jordan compared the commitment to “minority” students at HBCUs versus PWIs:

> It’s because they want to see you know the students succeed and like the professor’s here don’t I think it’s just they are trying to like help the minorities you know like they want more Black doctors you know and I think they’re just like trying to like help that happen (Jordan, cogenerative dialogue session, April 9, 2018)

When asked whether her professors had the same interests or concerns related to “minority” students, Jordan offered this response:

“I don’t think so because it’s not really focused on minorities you know like an HBCU it’s focused on African Americans.” (Jordan, cogenerative dialogue session, April 9, 2018)

There is a notable lack of diversity in the chemistry faculty at University of Georgia. There is currently one African American male professor in the chemistry department and no African American female faculty members. Jordan described her relationship with an African American teacher as being a significant part of her high school experience:

> There was only one Black teacher and she was like my mentor I love her her name is Dr. Hodges and she was the adviser of FBLA. I was the president of that and so I mean that was like the best part of high school for me. Even though I hate computers she did computer classes like intro to business and stuff even though I hated those I did that you know (Jordan, individual interview, June 6, 2018).

It was noteworthy that Jordan was willing to take classes that she was not interested in because of her relationship with Dr. Hodges. When asked how she developed such a strong relationship with Dr. Hodges, Jordan described a very organic progression:

> Well I remember when I first met her my friends they would like eat lunch in her classroom and so when like I went in there one day and I was like hey I would like to join FBLA and you know just through it out and we always had like fun times on field trips and stuff and like she was funny stuff and she wouldn't even know that she's like funny and so that's how like that happened and she was also just like I don't know I thought she'd want us to, you could talk to her. You know like yeah and it probably did have

something to do with her being African American (Jordan, individual interview, June 6, 2018).

The cogenerative dialogue sessions provided an opportunity for students to collectively share and reflect on their experiences in the freshman chemistry course. There were some personal stories from the sessions that would emerge as themes that would offer clarity regarding the students' experiences at University of Georgia and in the freshman chemistry course, as well as a glimpse into the experiences of other students.

Theme #1: Resistance to the "Weed Out" Culture

African American female students were the focus of this research investigation because of their negative academic outcomes in the freshman chemistry course. While African American females were more likely to withdraw from the course, African American females also earned a greater percentage (41.9%) of C's, D's, and F's in the course than other racial groups.

Myrtle and Jordan both described a culture in the course that worked to either intentionally or unintentionally "weed" students out of the freshman chemistry course. Myrtle described this climate from the very early days in the course:

> I think it is [a weed out course] because like I think yeah it is what you're saying like they psych people out a lot cause this one girl she like she was like oh I dropped freshman chemistry in the first week and I'm like really if you really want to do it you probably could you know like that's why I'm yeah hey I'm I haven't done very well on all the tests but you know I mean I want to do it I want to keep going you know like I'm not gonna let them psych me out (Myrtle, cogenerative dialogue session, April 9, 2018)

Myrtle discussed the attrition rate in the course. She believed it was important for students to feel supported by the faculty and that the professors wanted students to be successful in their STEM majors. In the following quote, Myrtle explained this weed out culture:

> Yeah like with that like when I like when we registered her stuff like that our class was packed like the first week of school and after the first test probably a lot of people withdrew because of that score and then after the second test a lot of people decided to withdraw so it was just like the increasing like it was just the test scores like those things I think they say like oh like nobody wants to be like in this major but I'm just like if the especially like if the tools or the resources are it's like the instructor isn't like openly trying to like say like we want you to succeed or we're doing this like people feel like oh this class is setting me up to fail and like a lot of people although people have that emotion like that class is like personally attacking them or something or like it's kind of like (Myrtle, cogenerative dialogue session, April 9, 2018)

Myrtle and Jordan were asked to cite specific evidence for why they believed the course was a weed out course at University of Georgia. Myrtle discussed the high percentage rate of students who are able to successfully pass the ACS final exam as evidence that the course was more difficult than the introductory coursework at comparable schools. Myrtle expressed this sentiment in the following quote:

> Okay so we have the ACS coming up and when everybody I've talked to who have previously taken the course they said that's like the easiest thing ever like that's test it's like much easier than our actual test that they make so I think that it is a weed out course because if ACS is the national test that's given to like chemistry classes then and our school is able to do it like our students are able to it really easily then that kind of is a

> weed out course because other schools like geared towards that test like they just focus on that test and material that's on there so just fill like it kind of is a weed out of course but then it's not because it's like we're UGA and we want to be above and beyond as well so like the content or like the look the difficulty is higher because they want you to succeed or have a better like foundation of this of the material (Myrtle, cogenerative dialogue session, April 9, 2018)

Myrtle and Jordan communicated a desire to resist the “weed out” culture of the course. In the following example, Myrtle explained that courses like the chemistry should not be a deterrent for students and that she was determined to work hard and be successful in the course:

> For this course like that's why I was I didn't like drop it or anything because I'm like courses like this come up like they're harder courses their courses that you just have to get acclimated with and get familiar with the way it's taught or just the material itself like I think my sister was the mechanical engineer like she was like there will be courses that will get you there will even entry-level courses it will get you it's just like you have to know do you want to do this is what you want to do and if so come back ten times harder (Myrtle, cogenerative dialogue session, April 9, 2018)

Jordan agreed that the course was intended to weed students out of STEM majors, but did not feel intimidated by the course early on like some of her peers:

> I do think it’s a weed out course because like everybody else you know that dropped like at the midpoint. They're all like I can’t do it it’s so hard and I was just like maybe it's my personality I was just like no chill you know it's alright (Jordan, individual interview, June 6, 2018)

Myrtle and Jordan both expressed disappointment at their final grades in the course, but Jordan's response came as a surprise to me. During our final interview, she never communicated any regret that she had not withdrawn from the chemistry course. Instead, she expressed pride that she had stuck with the course through all of her adversity:

> I was happy I didn't fail I felt that was something. And then the one other thing like I will be back. They didn't bring me down. They did not get me. I passed. I still technically passed. I wasn't gonna let them weed me out (Jordan, individual interview, June 6, 2018)

When we consider the academic outcomes for African American females, we must recognize that their goals and/or definition of success may be different than other mainstream students.

Theme #2: Racial Experiences & Lack of Diversity

This research investigation centered on the experiences of African American females in the freshman chemistry class at a predominantly White institution. When participants were asked if their experience in the course was different because of their race and/or gender, they were not able to articulate how or why it might be different than other students. Race continued to be the "elephant in the room." During Jordan's individual interview, she was able to capture the challenges she faced as a student of color in this academic setting. It is important to note that Jordan is biracial, but self-identified as African American for this study.

Jordan's high school was previously described as a large, public high school in an affluent community with a notable lack of diversity in the student body, but Jordan described it as the "rich white kids' school" during our conversation. She stated that there was only one Black teacher on the faculty and that she "could count the number of African-American students on two hands." Jordan had attended a predominantly White elementary, middle, and high school. University of Georgia was not her first choice for her post-secondary education because she wanted something “different.” Jordan expressed that she “finally wanted like a little bit of diversity” in her college experience, but when asked about her decision to not attend an HBCU, Jordan responded, “I didn't think I’d really fit in there either you know.”

Jordan was asked to specifically describe any aspects of freshman chemistry experience that were harder for her as an African American female. After some thought, Jordan offered, “maybe like forming study groups with people.” When I probed further, Jordan described an environment where students were cordial to each other on a surface level, “but not being comfortable maybe reaching out and developing friendships and real working relationships.” Jordan did not describe any specific negative experiences in lecture, but offered several generic scenarios to support her claim. Jordan expressed the sentiment that a White student would speak to an African American student, but would be more likely to ask a question of or work with another White student in the class:

> Like I don’t know I feel like it’s like subconsciously people are just like since we’re so different you know I would like speak to you and say hey but it’s you who I ask you a question or work with you.. you know you know (Jordan, individual interview, June 6, 2018)

In the following quote, Jordan described her belief that if given the choice a White student would be more likely to ask another White student a question or invite them to join a study group:

> But also do still feel like it's different but you know somehow like they wouldn't like if I was like sitting here and it's a like a White person was sitting here and her White person behind was bout to ask a question I feel like they’d ask them that kind of thing be like do you want to join a study group with them. (Jordan, individual interview, June 6, 2018)

Jordan's comments were a contradiction in many ways. On the one hand, Jordan said she was "learning to be friends with everyone", but went on to describe how she had voluntarily opted to sit with other African American students in lecture:

> I sat next to like some African-American students you know and that was like kind of my group that we all like helped each other there but you know I didn't really know anything about you know like the other side of the classroom (Jordan, individual interview, June 6, 2018)

When asked to explain her feelings about race, Jordan said that they were based on experiences prior to college and not at the university. She explained that White students would be less likely to ask a "minority" student to join a group because of the "uncomfortable factor". When asked what would make the students feel uncomfortable, Jordan shrugged her shoulders but said, "I've met a lot of racist people now in school."

Jordan shared three specific examples where she was a target of racist comments by other students at her high school. In the first example, a student continued to display the confederate flag and make inappropriate comments in class. Jordan would engage in a back and forth exchange with this student, but strongly believed that the classroom teacher actually contributed to this negative environment rather than resolving the dispute. Jordan expressed this sentiment in the following quote:

> Well Ms. Rosby, but she would she like to start stuff with the kids like cause there was this boy in the class and his name was Beau and he was younger than me and he like already had the Confederate flag on his phone and stuff and till he he like in the kids over they would always make like little snide comments so I would have to say something you know and she's like I would just end it cause I was like you know I'm not doing this

> anymore and one time she was like what's wrong Jordan you know what's wrong with me don't try to keep it going you hear this boy. (Jordan, individual interview, June 6, 2018)

The second example that Jordan shared involved a close, personal friend, but again Jordan did not feel supported by the high school faculty. Jordan recalled an incident where a friend walked up to her, put her arm around her, and called her my “nigga”:

> Yea I did get to cause this girl I was friends with since fourth grade um I’m not friends with her anymore I don’t know where she is but she what was it 10th grade she we were coming back from lunch and she like said Jordan my n word and I was like I went like crazy and I was like you can't say it I was like don't do and then like the parapro teacher she was like all right let's calm down you mean aint nobody gonna correct that. (Jordan, individual interview, June 6, 2018)

There has been a significant amount of discussion among the general public regarding the differences between the words “nigger” and “nigga”. The word “nigger” is a derogatory term with deep history of being used as a racial slur against Black people. The word “nigga” is commonly used in pop culture and in the African American community to refer to a close friend, but it is still very much taboo for the term to be used by a non-Black person.

The last example was deeply personal to Jordan as it touched at the very heart of her identity. Jordan shared an experience of sitting at the lunch table with two of her friends, when one of those friends stateed that the races should not “mix” and that mixed race children are an abomination. An abomination is defined as something regarded with disgust or hatred. In the following quote, Jordan painfully recalled the incident:

> It was me and my friend Kaylee and she's White and the girl Jennifer her name is Jennifer she was White and we were like sitting and eating breakfast one day and one of the very

> few Black kids in school walked past and Kaylee was like ooh he's fine you know and Jennifer was like um no you don't mix I said you do know I'm mixed right and she goes yeah and I'll she was like mixed children are an abomination I said are you my friend you told me I'm an abomination.

As a mother and educator, I found it very upsetting to hear Jordan describe these micro aggressions that she had experienced as a high school student. When asked to explain the source of this hostility, Jordan attributed it to a combination of factors. On the one hand, Jordan believed some of the students were intentionally spewing racist comments, but on the other hand Jordan thought that the lack of diversity contributed to a lack of awareness of how inappropriate the comments were to students of color. Jordan vividly recalls an environment where students routinely said racist things:

> There was a girl I thought was a good friend of mine but she like rode the bus with me and we had been friends for a long time but like she would just say racist things and I'm like do you not see nothing wrong with what' you're saying. (Jordan, individual interview, June 6, 2018)

When asked about her experience at University of Georgia, Jordan explained that she was pleasantly surprised by the diversity on campus:

> Yeah I mean it's better than what I expected it to be I didn't expect there to be any diversity at all, but there's a lot. (Jordan, cogenerative dialogue session, April 9, 2018).

While Jordan's experience may be unique to her mixed race status or her specific high school, it highlights the need to have more candid conversations about race on college campuses. Every student comes to the university with their own story and experiences with race. For some students, these experiences may be positive. For other students, these experiences may be negative. Regardless of the experience, it is these individual stories that will undoubtedly shape the extent to which students view themselves as a member of the academic community, are able to adjust to college life and to develop working relationships with members of other racial groups.

Cross-case Analysis

This chapter has presented a descriptive account of the cogenerative dialogue sessions that addressed the following research questions: a) what issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution; and b) what possible solutions are cogenerated by African American female undergraduate STEM students during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution? Critical issues identified include: a) instructional methods; b) assessments; c) course resources; d) isolation; e) lack of advisement; and f) detrimental effect on other coursework. Potential solutions discussed were: a) recitation sessions; b) TA training/development; c) a more robust chemistry resource center; d) development of structured study groups; and e) faculty selection. The final research question addressed in this section centered on the “stories” that emerged from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution. These stories were used to provide an explanation of the major themes presented by the young women in the study. Major themes identified include: a) isolation; b) relationships with faculty; c) role of social networks and a support system; d) resistance to a weed out culture; and e) racial experiences and a lack of diversity.

While each case provided valuable information, when we consider the collective cases further insight is provided into the experiences of African American female undergraduate STEM students in the freshman chemistry class at a predominantly White institution. One significant theme that emerged across both cases was related to previous high school experiences. Additionally, participants found their involvement in the study to be beneficial.

Previous High School Experiences

Previous research has examined the relationship between high school chemistry pedagogical experiences and performance in introductory college chemistry. Students who had high school chemistry courses that emphasized depth over breadth performed better than their counterparts (Tai, Sadler, & Loehr, 1995). In this study, participants who had experienced academic difficulty at the high school level in the more rigorous AP level coursework had better academic outcomes in the course than students who reported no difficulty in previous coursework.

Rickel had the best academic outcome in the course earning an A-. Rickel attended a science, math, and technology magnet high school with an 80% total minority enrollment. Her high school ranked among the top 5 in the state of Georgia and boasted a 100% AP participation rate. Rickel shared that her most negative academic experience and her least favorite high school teacher were both associated with the AP chemistry class. In her own words, Rickel discussed her experience:

> I failed that class I failed it like completely and it was it would…I know I was just I could not take that class and I went it was my junior year I took that class and I could not handle it I've had a mental breakdown it was terrible and I said I will redeem myself in college and I did (Rickel, cogenerative dialogue session, January 7, 2018).

Rickel described her teacher as having a disregard for the teaching profession. In this quote, she discussed the importance of feeling a connection to her teachers:

> Yeah she was why was she so bad I think I she's a teacher she's one of those teachers that you can tell she doesn't want to be a teacher more because she would always remind us I don't have to be a teacher I could go back to my forensic science job I was getting paid a lot more there all the time I heard that about ten times throughout the semester. I realized that that's a trait that I find I avoid in teachers now I like to connect with teachers and I don't think I can connect with the teacher that doesn't want to be a teacher and so. (Rickel, cogenerative dialogue session, January 7, 2018).

Rickel painfully discussed a pattern of favoritism in the AP chemistry course. This favoritism was hurtful because she was the only African American student in the course, it also impacted her confidence in her academic abilities.

> She the way she would say or put into words how she would go around the class helping people it sounded nice but as the semester progressed you can tell she had her favorites and so her favorites were always like the smartest of the bunch of smartest kids and it was kind of that specific point part of her her favoritism really hurt me I would say because I was the only Black person in the class and her favorites were always like the Indian bunch I would say just Asians in general but specifically she would always pick like the smartest people and that would make me feel like oh I'm not that smart she's not helping me like she's helping them and such like that and so uh she would play favorites. (Rickel, cogenerative dialogue session, January 7, 2018)

Finally, Rickel recalled an academic environment that was condescending to students who struggled with concepts. It was Rickel's belief that she would have been more successful in the course, if she had received more support from her teacher:

> Another thing she did was that she would always like get on you if you don't understand something that she thinks is so elementary so like I remember why was it valence electrons I couldn't understand she was like I think you should reconsider taking this class because this was in the beginning of the year because this is like a very fundamental thing and if you can't understand that but the thing was that I only came early in the morning to ask her for help only once if she had like helped me that morning I think I would have been okay would it understood valence electrons but it's almost like she looked down upon asking for help like we should get it the first time and I didn't I did not like that at all (Rickel, cogenerative dialogue session, January 7, 2018)

Nicole had the second best academic outcome in the course earning a B+. Nicole attended a large, public high school in the metro Atlanta area. The AP participation rate was 56% and the total minority enrollment was 57%. Nicole shared that her freshman year at University of Georgia mirrored her experience as a freshman in high school where she struggled in the AP biology class. Nicole shared, "I wasn't doing so hot like I did in high school" and "I actually had a couple meltdowns cause I grades and it brought me back to ninth grade year when I cried about my 40 on my math test."

Nicole attributed her academic difficulty to having poor study skills, but also the instructional methods used in the course. Nicole discussed her academic difficulty as a freshman:

> I think it’s because it was my freshman year but that was a struggle I took AP biology and I did not like that teacher she really didn't teach us all she had were PowerPoints and then we had packets and you know how there's a blank word in the packet and you read the PowerPoint and then write down the blank word that was basically it that's what she did and only two people got credit on the AP exam okay yeah of the students that she taught so she nobody liked her and then I kept getting C's on the test there's only one test it was molecular biology structures or something like that that I got an 88 and I was like finally thank goodness cause I've got so many C's that I just got comfortable getting C's I was like oh okay I another C. (Nicole, cogenerative dialogue session, November 12, 2017).

During conversations with Nicole and Rickel, both participants were able to connect the difficulty in the freshman chemistry course with their previous academic experiences. Rickel viewed the experience as a chance to vindicate herself and prove herself to her former AP chemistry teacher. Nicole was able to view the academic struggles as a short-term problem that would improve over time.

For the other participants, freshman chemistry was their first experience with academic difficulty. Marie had one of the more moderate academic outcomes in the course earning a C. Marie attended a large, public high school in the metro Atlanta area. The AP participation rate was 47% and the total minority enrollment was 54%. Marie did not take any AP coursework while in high school, but did participate in a dual-enrollment program. Marie reported that she had never experienced any academic difficulty prior to enrollment at University of Georgia.

As previously stated, Jordan attended a large, public school in Oconee County with an AP participation rate of 57% and a 20% total minority enrollment. Like Marie, Jordan had never experienced any academic difficulty prior to enrollment at University of Georgia. Jordan shared, “I've never failed a class before college, I'd never gotten C in any class in my life it was always an A or B.” Jordan discussed the challenges of adjusting to college level work:

> Well it’s not like high school you know in high school I could usually get by without studying that much you know just leave class and you know throw your book bag away that’s what I would do but here you can't do that stuff in college I learned that you got actually like study” (Jordan, individual interview, June 6, 2018)

When asked why she opted not take more advanced coursework in high school, Jordan explained, “I didn’t wanna mess up that GPA like I did this past semester” and “I wasn't gonna like stress myself out you know.”

African American students who are interested in pursuing a STEM degree must be encouraged to take the most rigorous courses available at the high school level. It may be very important for students to experience this academic difficulty in an environment where they still have the support of teachers and parents.

Benefits of Participation in Study

All participants reported that their involvement in the cogenerative dialogue sessions was beneficial, providing an opportunity to discuss challenges associated with the course and learn more about course resources. Nicole shared that the sessions allowed her to discuss her emotions related to the course:

> I like the fact that we were able to talk about like we had common interests and how we didn’t like chemistry and we didn't like how things are you know sometimes it’s nice to say what's troubling you and you know to not bottle it in because I usually bottle in my emotions cause I'm introvert but it was nice like get it out on the table like chemistry

bubbeleh I can't believe this test I got a freaking 58 or so blah blah yeah and the Chem lab is awful. (Nicole, cogenerative dialogue session, January 7, 2018)

In this quote, Marie discussed how she was able to talk about the course and learn new study strategies:

> It's good to know that you're not the only one struggling at something It's good to talk about everything you wish could happen it's like good to know that like other people's way of them studying coping with the course so that you can change like what you're doing I think it would be better if there's a lot more people like I think that would just help some yeah (Marie, cogenerative dialogue session, January 7, 2018)

Jordan shared that the sessions helped her to develop a relationship with Myrtle and affirmed that she was not the only student struggling in the chemistry course:

> Well that's how you know I really got talking to Myrtle and that's how me and her started studying together. My experience in the course would have been a lot different. I really don't think I would have known like how like kids I mean the point of this is that some people are struggling with it right I wouldn't have known you know. I didn't feel like I was the only person struggling, but I know like everybody else around me was were getting better grades than me at least after the drop period (Jordan, individual interview, June 6, 2018).

Rickel expressed how the sessions were helpful to learn about additional resources and to share her experience in the course:

> I liked how through the talking I found out about Science guyz and I found out about the MLC tutoring sessions um that I didn't know people would go to these things and I'd be like how do you get there how do you find out so that that this gave me like a source of

> like help if I needed extra help I can't I can't think of anything I would change honestly I think it'd be cool to have like more people that is larger but I can't think of anything to change really and it helped to talk about um like your issues or whatever because you would find out that you're not alone like everybody's going through it (Rickel, cogenerative dialogue session, January 7, 2018)

This research utilized Black Feminist Thought as a theoretical framework for this study. Black feminist Thought strives to develop "facts and theories about the Black female experience that will clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16). As valuable as the cogenerative dialogue sessions and individual interviews were to the data collection and analysis process, the photo-elicitation exercise offered additional insight into the lives of these African American female STEM students.

Elicitation techniques use visual, verbal, or written stimuli to encourage people to share their ideas (Johnson & Weller, 2002) and provide "useful alternatives to direct questions about participants' thinking, particularly when social, cultural, or psychological barriers make it difficult to talk about a topic" (Barton, 2015). During the fall semester, participants were asked to provide photos to be used in an elicitation exercise.

Participants were first asked to select a picture that represents how they see themselves as an individual and as a STEM student. For her first picture, Nicole selected an image of Mulan, an iconic Disney princess who secretly disguises herself as a man in order to enlist in the Chinese military. She stated,

> I chose Mulan because like her I am a warrior and I never give up. Also, this picture depicts how she is tom-boy and a girly girl; that is how I describe myself.

Figure 1. Nicole's image "Mulan."

For her second picture, Nicole selected the cover image for the film, Hidden Figures. Hidden Figures is the story of Katherine Jonson, Dorothy Vaughan and Mary Jackson, three African-American women who worked at NASA and were instrumental behind the launch into orbit of astronaut John Glenn. Nicole described the picture:

> This picture is how I see myself as a STEM student because these ladies are strong, bold, powerful, and intellectual. And that is how I see myself as a female engineering student.

Figure 2. Nicole's Image "Hidden Figures."

Marie selected several self-portraits for this exercise that will not be displayed to protect her identity. In the first picture, Marie is outside standing in front of a tree on a sunny day. She is smiling and dressed in a black business suit on her way to a conference. When asked why she selected this picture, she stated, "I see myself in a professional way working towards my goal of becoming a doctor." Her second picture was a picture of her dressed in workout attire standing in the gym. Marie shared that because of her dual enrollment schedule, she had actually gained a lot of weight during her senior year of high school. Since arriving on campus, Marie has made a conscious effort to eat better and exercise on a regular basis. She explained, "I see myself in a more positive light because I've become much healthier."

Rickel also provided a self-portrait as a description of how she sees herself as an individual and as a STEM student. In this picture, Rickel is standing in front of a wooden door. She is wearing a royal blue sweater and light colored jeans. She has a broad smile on her face and her hair is styled in a large, natural Afro. When asked about her selection, she offered the following explanation:

> I love that picture because I was just in my element and that sort of shows me because I'm like a genuinely happy person I like to have fun like that was fun and I was by myself and also in there I see a lot of like of my grandma's looks in that specific picture she's Jamaican and she has all these stories about how when she was growing up she was the finest thing in town and so I kind of like look that kind of reminded me of my grandma and so like it made me appreciate my culture and such like that so that's how I just view myself as and especially since um I just like I just like me it took me a lot of time to like me but now I really like me and so like that's how I view myself and how I want to represent myself.

For the second part of the exercise, participants were asked select a picture that represents how others perceive them as an individual and as a STEM student. Nicole selected another image of Katherine Jonson, the scientist from the movie Hidden Figures. In this picture, Ms. Jonson is standing on a ladder working a math problem on a chalk board. Nicole explained:

All the people who really know me know that I am great at math. They always come to me for help.

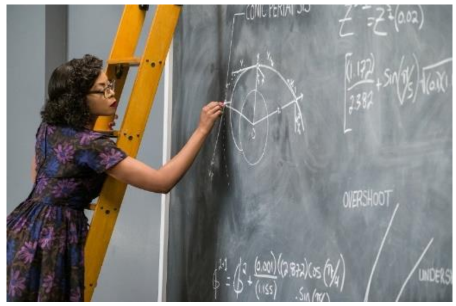

Figure 3. Nicole's image "Math."

The second image selected by Nicole was actually an infographic entitled "STEM Facts on Women & Girls". The infographic shows the underrepresentation of women and minorities in STEM careers including the issues related to economic inequality and retention issues. Nicole explains why she selected the graphic:

> This is how men and other people in charge of the STEM field perceive me and my other fellow women as. They view us as less than and inferior, but in reality, we are smarter and have more intelligence and dedication under our belts. Furthermore, as African American female, it is even harder for me because I have more hoops to jump through and more people to prove wrong.

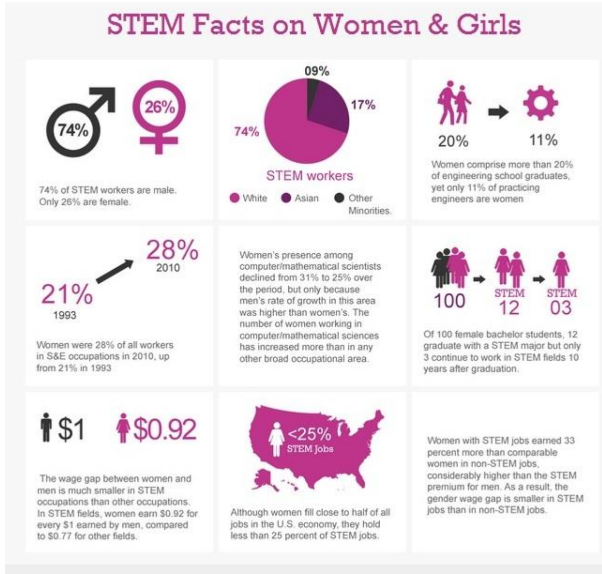

Figure 4. Nicole's Image "STEM Facts on Women & Girls."

Marie selected another self-portrait but in this image her face is not visible. It displays her long, black hair as she talks about how others constantly question her "Blackness" because of her appearance, affluent background and private school education. Marie stated,

> Others see me as "not Black" because of my hair, skin color, the way I talk etc.

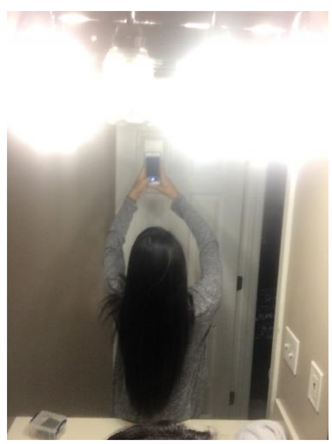

Figure 5. Marie's Image, "Not Black."

Rickel selected a picture of Alexa Irene Canady, the first African American female neurosurgeon, to represent how other view her as an individual and STEM student. She stated, That is Alexa Irene Canady and she was the first female Black neurosurgeon and I talk all about my dreams to like my friends and my family and such like that so I kind of instill what I want to be in the future in my friends and family so that they know what my future goal is and that they can help me work towards what I eventually want to become and so I look up to her and I kind of view her as well how people see me because that's kind of the track I want to go on and also she herself is just an amazing like inspiration for me so yeah that's why I think people that's how I want people to see me kind of.

Figure 6. Rickel's Image "Alexa Irene Canady"

When asked if she would have selected the same picture in August, Rickel explained:

No, I wouldn't have selected Alexa because before I took the chemistry class and my sciences that I took over the summer those really solidified the fact that I do want to go in medicine I know it's new I wanted to go in medicine but there was like a little thing in me that said oh you know cause stereotypes I don't think I could really become a neurosurgeon there's only like like 1 100 out of 300 neurosurgeons are female and I'm sure less than that are Black so I was like kind of talking myself down but now that I got through the chemistry classes I think I can do it kind of especially since everybody was saying that chemistry's like the hardest thing and I survived it.

Each participant offered a unique approach and perspective to the photo-elicitation exercise. The importance of Black women's self-definition and self-valuation is a central theme to Black Feminist Thought. Self-definition involves" challenging the political knowledge-validation process that has resulted in externally-defined, stereotypical images" of what it means to be a Black woman and self-valuation "stresses the content of Black women's self-definitions," that is the need to replace these images with "authentic Black female images" (Collins, 1986, p. 16). Participants offered "authentic Black female images" of Black women who were beautiful, intelligent, professional, successful, and healthy. These images seemed to play a critical role in the participants' ability to persist despite adversity and actualize their dreams of becoming STEM professionals.

During the spring semester, participants were given different instructions for the photo-elicitation exercise. Participants were first asked to comment on photos provided by the primary researcher. The selected photos included photos provided by the fall semester participants and additional photos chosen by the primary researcher.

One of the photos selected was a picture of the chemistry faculty at University of Georgia. Jordan immediately recognized the photo as a faculty picture, but not the specific department. When asked to describe what stood out to her about the photo, Jordan stated, "There's one Black person." She slowly added the following descriptors: mostly men, old, and white, grey hair. Jordan went on to discuss the absence of other "minority" groups including Latino and Asian faculty members. I asked Jordan, "How do you feel as an African American female who's interested in science when you look at pictures like these?" She responded, "I feel there's an under-representation is that the right word." Next, I asked, "Do you think there's a place for you?" Her response made me smile. She stated, "No, but I'll make one!"

For the final part of the elicitation exercise, Jordan was asked, “If you were to pick a picture what sort of image would you have selected?” Jordan responded:

I see I see…me sitting in the back of the classroom with a confused look on my face in the dark, the light overhead of me, is just dark just a sad picture. Everybody else is raising their hand cause they know the answer to the question and I don't. (Jordan, individual interview, June 6, 2018).

I found Jordan’s response and body language to be troubling. I probed further, “Why would it be sadness?” She simply stated, “Because I don't know nothing.”

I asked Jordan one final question, “ If other people around you either in lecture or lab or your professors or whoever you want to pick what do you think they see what they see when they see you? Her response surprised me and I found myself struggling to hold back tears. She stated, “Pity…I get bad grades, pity, she's pity, she's pitiful for me whatever it is I'm pitiful there we go.”

Jordan also offered a unique approach and perspective to the photo-elicitation exercise. There was a pattern of self-deprecation to many of her responses, often disguised behind humor. There was also a sadness, a sense of hopelessness as she struggled to make sense of her experience in the freshman chemistry course. As Jordan discussed her plans for the future, I was left wondering about the emotional toll and any lasting negative impact on her self-esteem and her ability to become a successful STEM student. Myrtle the other student who had a negative academic outcome in the course, opted out of the final individual interview and photo-elicitation exercise, citing personal reasons. As I reflected on Jordan’s responses, I wondered about the impact on Myrtle. Although she had previously discussed some health issues and some personal problems including the divorce of her parents, I was curious about the real reason for her withdrawal from the study. Was Myrtle too busy or was the idea of talking about her academic failure simply too painful for her?

Chapter Summary

This chapter presented a description of the findings from the data collection and analysis process, beginning with a description of the context for each case. Next, the critical issues associated with the course were discussed including potential solutions to these concerns. Finally, this chapter highlighted the most salient themes that "emerged" from both cases and ends with a cross-case analysis in order to further understand the unique experiences of African American female students in freshman chemistry course at a predominantly White institution. The next chapter will provide a discussion, implications, and recommendations for future research.

CHAPTER 5

DISCUSSION AND IMPLICATIONS

This study was an investigation of the experiences of African American female, undergraduate STEM students at a predominantly White institution (PWI). Black Feminist Thought was used as the theoretical framework for this study as it sought to develop "facts and theories about the Black female experience that would clarify a Black women's standpoint for Black women" (Collins, 1986, p. 16). This research study consisted of two distinct case experiences held during the fall and spring semesters at the University of Georgia. The primary researcher conducted a series of co-generative dialogue sessions, semi-structured interviews, and a photo-elicitation exercise with five African American female, undergraduate STEM students. Each participant self-identified as Black, as a female, and as a STEM student with a declared major requiring completion of the freshman chemistry course. This study was guided by the following research questions:

1. What issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution?
2. What "stories" emerge from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution?

3. What possible solutions are cogenerated by African American female undergraduate STEM students during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution?

This chapter includes a discussion, implications, and recommendations for future research. The discussion is an interpretation of the findings in terms of theory and previous research. The implications include recommendations for practitioners in K-12 education, chemistry department faculty, and university administration. The recommendations for future research offers guidance to graduate students, STEM faculty, and university programs on additional research investigations that will expand our current knowledge related to experiences in the freshman chemistry course.

Discussion

The purpose of this study was to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. Additionally, this research sought to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution.

According to Tsui (2007), previous research has identified ten intervention strategies that are commonly implemented by programs that strive to increase diversity in STEM fields. The intervention strategies include: a) summer bridge; b) mentoring; c) research experience; d) tutoring; e) career counseling and awareness; f) learning center; g) workshops and seminars; h) academic advising; i) financial support; and j) curriculum and instructional reform. While this research does not focus solely on African American females, these intervention strategies have previously shown success with “minority” populations. In the current study, research experience, career counseling and awareness, workshops and seminars, and financial support did not emerge in the discussion of critical issues, emerging themes, and potential solutions for the freshman chemistry course. Research findings will be discussed in the context of the six intervention strategies from this existing body of literature that were presented during this research investigation.

Summer Bridge Programs

Summer bridge program is a commonly used term to describe “multi-week intensive experiences that occur in the weeks before a student’s first year of college or a transfer student’s entry into a 4-year institution” (Ashley, Cooper, Cala, & Brownell, 2017, p. 1). While the goals of summer bridge programs may vary by institution, Ashley, Cooper, Cala & Brownwell (2017) classified summer bridge program goals into three main categories: a) academic success goals; b) psychosocial goals; and c) department-level goals. Previous research indicates that summer bridge programs play an integral role in the success of intervention programs (Tsui, 2007).

Benefits of summer bridge program participation were discussed by participants in this research investigation. Of the five research participants, Rickel was the only student to attend the summer bridge program at the University of Georgia. Her experience may have influenced her outlook regarding three themes that emerged in this study: a) isolation; b) relationships with faculty; and c) role of social networks and support systems.

African American female participants described feelings of isolation as members of an underrepresented “minority” in the area of STEM. This isolation was augmented by the phenomenon of “instant friendships” and introverted personality characteristics. Rickel was the only participant who regularly studied with other chemistry students which reduced these feelings of isolation. She described her involvement in study groups and how her participation had improved her understanding of the chemistry content. Her participation in the summer bridge program seemed to enhance her ability to form important networks and establish relationships with faculty and peers.

Educational research has emphasized the importance of relationships between teachers and students in academic settings. Relationships played a significant role in the participants' feelings about the course. Rickel described positive relationships with her chemistry professor and teaching assistants. She had the best academic outcome in the course of all the research participants earning an A- as her final course grade.

Social networks and support systems provided an additional level of support in the course. Rickel's support network was more extensive than the other participants including students and faculty from the summer bridge program. This network served to provide her with supplemental resources, study aids, and tutorial support in the course.

Mentoring Relationships

A mentoring relationship is a relationship between a "seasoned, experienced person, a mentor, and a less experienced person, the protégé (Estrada, Hernandez & Schultz, 2018; Rhodes, 2005). According to Eby et al (2013), three factors must be present in order for the protégé to experience a positive outcome as a result of this mentoring relationship. These factors are best characterized as instrumental support, psychosocial support, and relationship quality (Estrada, Hernandez & Schultz, 2018). A positive mentoring experience was identified in a study conducted by Tsui (2007) as the "single-most important factor identified in students' degree attainment" (p. 559).

The positive aspects of mentoring relationships were highlighted during this research investigation. The role of mentoring was evident in key themes that emerged in this study: a) relationships with faculty; b) role of social networks and support systems; c) previous high school experiences; and d) benefits of participation in the study.

Relationships with faculty served as an informal mentorship for the participants. Rickel and Nicole both described the instrumental support provided by their respective chemistry professors. This relationship offered support with course content, study skills, and academic motivation. Rickel also discussed her career aspirations of becoming a neurosurgeon with her professor.

The role of social networks and support systems was another theme that highlighted the importance of mentoring to the African American female participants. Family members and peers were frequently mentioned as a source of mentoring support. Nicole, Myrtle, Rickel, Jordan and Marie each shared a specific story of how one or both of their parents had offered advice and encouragement during the freshman chemistry course. Rickel's peers were able to offer her informal tutoring, study materials, and course recommendations. Additionally, participants discussed academic and career advice gained through their involvement in campus organizations such as National Society of Black Engineers (NSBE), Louis Stokes Alliances for Minority Participation (LSAMP), and Minority Student Science Association (MSSA).

Previous high school experience was a third source of informal mentoring that participants found beneficial. Rickel discussed how her psychology teacher influenced her interest in neuroscience. Jordan described her relationship with the only African American teacher, Dr. Hodges as being a significant part of her high school experience. Dr. Hodges served as a role model, encouraged Jordan to develop her leadership skills, and continued to serve as a mentor following her matriculation at the University of Georgia.

Benefits of participation in the study was the fourth and final manner in which mentoring played a role in this research investigation. All participants reported that their involvement in the co-generative dialogue sessions was beneficial, providing an opportunity to discuss challenges associated with the course and learn more about course resources from one another. From early on in the research study, it became clear that the primary researcher had taken on the role of mentor to the younger, African American female STEM students. As a teaching assistant, researcher, and graduate student who had successfully navigated the world of STEM, the researcher was able to serve as an advisor, friend, and maternal figure offering informal advisement, academic support, and career counseling.

Tutorial Programs

Tutorial is a commonly used intervention strategy to offer additional academic support to underrepresented students in STEM programs. This tutorial can be offered in a variety of formats. It can be facilitated by faculty members, teaching assistants, upperclassman, or peers. It can be offered on a one-on-one, small group, or large group basis. Some tutorial is free to students while other students pursue paid services through private tutors. Previous research has demonstrated many positive effects for students who regular attend tutorial including enrollment status, persistence, and cumulative GPA (Cooper, 2010; Tsui, 2007).

Tutorial attendance was discussed by participants during this research investigation. While students reported that they did not regularly attend “drop-in” tutorial, benefits of faculty office hours and peer tutorial were discussed. Rickel and Nicole, who were the only participants who reported attending office hours offered by their chemistry professor, earned the highest course grades in the freshman chemistry course with an A- and B+, respectively. Rickel and

Jordan both shared positive experiences with peer tutorial and cited specific examples of how it improved their understanding of course content.

Learning Center

Learning centers or learning assistance centers (LACs) first appeared on college campuses in the 1970s, but this intervention has quickly become a key component in higher education's integrated approach to improve the academic performance and graduation rates for college students (Arendale, 2004). According to Arendale (2004), there were four factors that influenced the development of today's modern learning centers: a) changes to federal policies and economic programs; b) growing student enrollment; c) increasing diversity on college campuses; and d) high rates of student departure. Christ (1971) identified six purposes to be accomplished by a learning center: a) increased academic achievement; b) centralized location; c) coordinate support across multiple agencies; d) comprehensive library of academic resources; e) training for teaching assistants, counselors, and tutors; and f) faculty development.

The chemistry learning center at the University of Georgia was another factor identified by participants in this research study, not because of its success, but more so because of its perceived failure to provide academic support to students in the freshman chemistry course. Participants cited confusion related to the tutoring opportunities available, "hit-or-miss" experiences with tutors, failure to communicate information related to services, and lack of coordination between campus agencies as major concerns related to the chemistry learning center. Historically, campus learning centers have been on the cutting edge of instructional strategies, technology, and faculty development. According to the participants, the chemistry learning center is currently falling short of accomplishing many of these intended goals and could be an important resource to address critical issues and possible solutions identified by the researcher including instructional methods, assessments, course resources, TA training/development, and faculty selection.

Academic Advisement

Academic advisement is a widely used intervention strategy and has been identified as a "foundational" factor in student retention and degree completion (Cueso, 2003; Rodgers, Blunt & Trible, 2014). Advisement is likely to occur once a semester at most institutions or when a student is placed on academic probation. Seymour and Hewitt (1997) found that STEM students were very likely to be dissatisfied with academic advisement with the advisement process being described as "confusing," "unreliable," "inadequate," and "impersonal". According to Seymour and Hewitt (1997), this factor is of greater importance to female and "minority" students who are more likely to lack confidence in their science ability and have previously received encouragement to pursue a STEM field from a particular high school teacher.

Academic advisement or the "lack of advisement" was identified as a critical issue in this research investigation. While Nicole shared a negative experience during a visit with her academic advisor, Jordan and Myrtle displayed a greater need for high-quality advisement. Both students were experiencing academic difficulty and in danger of failing the chemistry course at the start of the research study. Despite their academic concerns, neither student had discussed their options for withdrawal with academic advisors or chemistry faculty. Additionally, they communicated questions related to how a course withdrawal might influence housing eligibility, financial aid, and academic standing at the institution. Myrtle and Jordan's final course grades were a C- and D, respectively. Another area of concern related to advisement was the extent to which their persistence in the chemistry course had a detrimental effect on their other course work.

Curriculum and Instructional Reform

Many research studies have attempted to gain an understanding of why students leave the sciences. STEM faculty members have long claimed that attrition rates are due to students who lacked the academic preparation, motivation, or natural aptitude to succeed in STEM majors, but the research does not support this claim. Current initiatives have advocated curriculum reform in order to address these problems in STEM undergraduate education. Several improvements have been implemented in recent years by the University of Georgia, but participants discussed the need for additional reform.

Instructional methods were a significant area of concern for participants during the co-generative dialogue sessions. Participants expressed frustration with the “flipped” classroom model, describing this instructional model as an ineffective use of time and stated that clicker learning activities did not improve their understanding of the content. While previous research has found that “flipped” classrooms offer a number of benefits for students, “the particular challenge with large classes is in enacting the active learning component” (Robert, Lewis, Oueini, & Mapugay, 2016, p. 1994). According to Robert et al. (2016), for larger classes this active learning centers on problem-solving sessions through the use of classroom response systems and the aid of graduate teaching assistants. It is notable that the freshman chemistry course at the University of Georgia did not utilize graduate teaching assistants which may have interfered with the ability to answer student questions, probe for explanations of student work, and the general proper implementation of this instructional model.

Assessment was another issue raised during the co-generative dialogue sessions. Participants raised concerns related to the course grading structure and the use of WebAssign, a digital assessment tool used in the chemistry course. While WebAssign offers significant advantages for assessments including automatic grading of assignments, release of exams, and randomization of questions, participants did not feel that it offered an accurate assessment of their chemistry knowledge. Opportunities for partial credit were minimal and students stated that small math errors or formatting issues could have a significant impact on exam performance. Pienta (2015) discussed the challenges associated with testing in large lecture courses of general chemistry. There are advantages and disadvantages associated with both traditional paper-based and computer-based testing, Pienta (2015) urged the chemical education community to shift the focus away from how students are assessed (scantron vs computer) to what knowledge is assessed (process of solving problems vs conceptual understanding) in the general chemistry course.

Implications for Practice

This chapter has discussed research findings in terms of theory and previous research. Based on the findings of this research study, there are some explicit implications for the K-12 educational system, chemistry departments, university faculty, and higher education administration.

K-12 Educational System

According to Campbell (1996), by the age of 13 years old the majority of "minority" students have been removed from the early pathways that lead to the advanced study of mathematics and sciences. If "minority" students do no acquire the prerequisite mathematics background, regardless of interest, these students will not be competitive to pursue a number of careers including the physical sciences and engineering (Anderson, 1990). Even high-achieving minority students were found not to reach their full potential without role models and the necessary support at the college level (Arnold, 1993; Tsui, 2007). One of the findings of this research study was that participants who had experienced academic difficulty at the high school level in the more rigorous AP level coursework had better academic outcomes in the course than students who reported no difficulty in previous coursework. Based on this research, some suggestions for K-12 educators are:

1. For guidance counselors to educate parents and students in order to increase the likelihood that college bound “minority” students are placed in advanced math and science courses that will provide the necessary foundation for STEM pathways.
2. To encourage “minority” students to enroll in advanced level science and math courses through advanced placement (AP) or dual enrollment programs.
3. To provide career counseling and awareness to “minority” students who are interested in pursuing STEM majors including mentorships and opportunities to job shadow or complete externships.

Chemistry Departments

According to Tai, Sadler, and Loehr (2005), chemistry is viewed as the central science, as mastery of its concepts is essential to further coursework in all of the sciences. Evidence for this belief lies in the order of coursework required at many major universities in the United States. (p.988). Astin and Astin (1993) found that the greatest losses of students changing from STEM to non-STEM majors occur at or before enrollment in college. After students begin their undergraduate experience, they are most likely to transition to a non-STEM major at the end of their first year. Many students decide to pursue non-STEM majors at the end of their freshman year when they are not able to perform well enough to ensure their competitiveness and acceptance into professional programs. According to House (1996), student achievement in introductory college science courses is important because a large number of career options in the basic sciences, engineering, and health sciences require satisfactory grades to enroll in more advanced courses. Based on this research, some suggestions for chemistry faculty and department coordinators are:

1. Chemistry departments are encouraged to conduct regular program evaluations and needs assessments to gauge the effectiveness of chemistry learning centers and supplemental instruction programs. This process could facilitate the removal of programs that are not being utilized and initiate dialogue regarding programs that would be more current, relevant and beneficial for students.
2. The selection process for graduate teaching assistant opportunities should become a more competitive process, to include campus-wide searches to identify the most talented students to serve as the first point of contact with freshman students. Additionally, graduate teaching assistants should be required to complete mandatory pedagogical and diversity training for continued employment to ensure they are equipped to meet the needs of targeted students.
3. Campus resources available for introductory classes should be better coordinated with the chemistry department and teaching faculty to ensure that all offices can communicate accurate information to students. This would improve the communication of available resources and promote broader participation in tutorial, review sessions, and other academic initiatives.

University Administration

While HBCUs make up less than three percent of U.S. postsecondary institutions, they demonstrate considerable success in awarding degrees to Black students. While there has been moderate, national improvement in STEM graduation among Black students, HBCUs continue to play a prevalent role in increasing the number of "minorities" in the sciences (Guzman & Nyugen, 2014). The percentage of Black students who attend HBCUs has steadily declined from 90% in 1960 to 8% today (, 2015). Research indicates that Black students attending PWIs are less likely to graduate with STEM degrees. Faculty and administration at predominately White institutions (PWIs) will need to take action to address the changing demographics on campus and meet the needs of more diverse student populations. Based on this research, some suggestions for university administrators are:

1. University administration should work to ensure the integration, proper implementation and equitable access to these ten research-based intervention strategies (Tsui, 2007) on college campuses.
2. Departments must work to ensure that all undergraduate students including women and "minorities" have the opportunity to receive high-quality academic advisement on a regular basis. Additionally, as enrollment rates increase and campuses become more diverse, departments may have to consider the implementation of "intrusive" or more aggressive advisement programs.
3. University administration should work to not only recruit, but retain faculty members who represent underrepresented "minority" groups. Additionally, through a social justice agenda and diversity initiative, university administration should ensure that faculty receive the training and support necessary to meet the needs of each and every student that enrolls in their courses.

Recommendations for Future Research

The purpose of this study was to collectively identify critical issues in the freshman chemistry course and cogenerate solutions to improve the learning experience and academic outcome for Black female, undergraduate STEM students. This research sought to offer a platform to this population of Black women from diverse backgrounds to share their experiences in freshman chemistry at a predominantly White institution. This researcher believes that even more valuable information could be attained by expanding the current research study to include a larger population from the University of Georgia or a population from a comparable institution. Additionally, a similar investigation of African American females who attend a historically Black college or university (HBCU), such as Spelman College, could provide additional insights. Such a study would foster an in depth exploration of the factors that contribute to the disproportionate number of STEM degrees awarded to Black students in a different academic context.

Although this investigation was focused on Black females, academic challenges in the freshman chemistry course are certainly not isolated to Black female students. Research is also needed to investigate the academic performance and experiences of African American males, Latino males, and Latino females. Each of these groups experienced higher than average withdrawal rates and high percentages of C's, D's and F's as final course grades in the freshman chemistry course at the University of Georgia at the time of this research investigation. Asian American students would be another population of interest based on their performance. The Asian American population consists of many micro-groups from East Asia, Southeast Asia, and South Asia. Asian American students displayed a bimodal grade distribution with students either performing very well or very poorly in the freshman chemistry course at the time of this research investigation. Additional research is also needed to investigate the experiences of students with disabilities in the freshman chemistry course. Historically, students with disabilities have experienced a multitude of barriers that do not allow them to access STEM education at the same rates as students without disabilities. Further research is needed to explore this diverse population, specifically, in terms of factors that contribute to the academic success and/or failure of these students in freshman chemistry.

Conclusion

According to Jackson (2007), there exists a quiet crisis in the United States. This crisis refers to United States' inability to produce the scientific and technical talent necessary to maintain our economic advantage and support national security interests. This shortage in STEM talent is being fuel by a number of factors, including an aging workforce, global competition, and stagnant interest in STEM disciplines. The inability of the United States to attract young talent, coupled with increasing concerns related to our national security and declining economy, make the retention of STEM undergraduate students a vitally important research area. The goal of this research investigation was to expand our knowledge of the experiences of African American females in the freshman chemistry course at a predominantly White institution and educate the science education community. Through this work, it is hoped that we might move one step closer to ending this "quiet crisis" in the United States and to ensure that all students receive the support necessary to succeed in STEM fields.

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APPENDICES

APPENDIX A

Recruitment Form

My name is Natasha Johnson and I am a doctoral student at the University of Georgia in the Department of Mathematics and Science Education. I am interested in talking to you about your experiences in freshman chemistry for my study entitled "African American Female Undergraduate STEM Majors Experiences in Freshman Chemistry." The purpose of this study is to understand experiences by African American female undergraduate STEM students in freshman chemistry at a predominantly White institution. I am hoping that the results of this study will help to inform academic interventions available to chemistry students and improve the undergraduate science experience. I would be grateful for your time and participation.

In order to be a participant in this study you must:

- Identify as an African American
- Identify as a female;
- Be currently enrolled in the CHEM 1211 course;
- Be willing to participate in a total of 3-4 co-generative dialogue sessions.

There are two ways to contact me if you are interested in participating in this study:

If anonymity is of concern:

- Choose a pseudonym (name, not your own) for the study
- Call me at (678) 849-4834 (Select *67 prior to placing the call to block caller ID)
- Identify yourself by the name you have chosen. (If we do not make contact, please leave a message and try again later. If contact is made we can talk about the details of the study.) For the duration of your participation in the study I will address you by the pseudonym you have chosen.

If anonymity is of no concern:

- Call me at (678) 849-4834 or
- Email me at yjohnson@uga.edu or
- Send me a note by paper mail to: (Insert university address)
- Be sure to provide your name, daytime and evening phone, best time to call, and email address.

Thank you for your interest in this study.
I look forward to discussing it further with you.

APPENDIX B

Demographic Information

1. Age: ________ (years)

2. Gender: ________ Female

3. Ethnicity: ________ African American/Black

4. Hometown: ___________________________ (City, State)

5. High School Attended: ___________________________

6. Description of High School Coursework (Math, Science, Honors, AP/IB, etc)
____
____

7. Your Educational Level:
   ________ (1) 1st Year
   ________ (2) 2nd Year
   ________ (3) 3rd Year
   ________ (4) 4th Year

8. Intended Major (check all that apply):
   ________ (1) Science (Biology, Chemistry, Physics)
   ________ (2) Mathematics
   ________ (3) Computer Science
   ________ (4) Engineering
   ________ (5) Professional (Pre-Medicine, Pre-Dentistry, Pre-Pharmacy, etc.)
   ________ (6) Other Sciences (   )

9. Parents' Highest Educational Level

Mother or guardian (check one)

________ (1) No Diploma
________ (2) High School or GED
________ (3) Some College
________ (4) Associate's Degree
________ (5) Bachelor's Degree
________ (6) Master's Degree or Higher
________ (7) I don't know

Father or guardian (check one)

________ (1) No Diploma
________ (2) High School or GED
________ (3) Some College
________ (4) Associate's Degree
________ (5) Bachelor's Degree
________ (6) Master's Degree or Higher
________ (7) I don't know

10. Chemistry Coursework:
Are you currently enrolled or have you recently taken CHEM 1211? Yes/ No
Semester ________ Year ___________

Grades: Exam 1_______Exam 2 _______Exam 3 _______Exam 4 _______Final________

Final Course Grade ______

APPENDIX C
Research Project Consent Form

I, ____, agree to participate in a research study conducted by Natasha Hillsman Johnson, a doctoral student from the Department of Mathematics and Science Education at the University of Georgia (telephone: 678-849-4834; email: yjohnson@uga.edu) under the directions of Drs. David Jackson and Deborah Tippins, Department of Mathematics and Science Education, University of Georgia. I understand that my participation is voluntary. I can withdraw my participation at any time without giving any reason, and without any penalty. I can ask to have all of the information about me, to the extent that it can be identified as mine, returned to me, removed from the research records, or destroyed.

I understand that the purpose of this study is to understand experiences of African American female undergraduate STEM students in freshman chemistry at a predominantly White institution.

If I volunteer to take part in this study, I understand that:

- I will participate in 7-8 sixty minute co-generative dialogue sessions.
- The researcher will ask.
- My interviews will be audio taped and pseudonyms will be used in an effort to keep my identity confidential. The audio tapes will be locked in a secure file cabinet located in the researcher's off-campus office, and will only be accessible to the researcher.
- I may be asked by the researcher to suggest other participants who may be willing to participate in the study.

The researcher is hopeful that my participation in the study will allow me to thoughtfully consider my own experiences in freshman chemistry, and that my participation could lead to new academic interventions designed to address the needs of African American female undergraduate STEM students. No risk is expected, however if I experience any discomfort or concern about my participation, I may contact the researcher at any time during or after the completion of the study.

The investigator will answer any further questions about the research, now or during the course of the project (678-849-4834). No information identifying me will be shared with others without my written permission. All information concerning me will be kept confidential.

I understand that by signing this consent form, I am agreeing to take part in this research project and understand that I will receive a signed copy for my records. Please sign both copies, keep one and return one to the researcher.

____ ____________________

Signature of Participant Date

____ ____________________

Natasha Hillsman Johnson (Investigator) Date
(678) 849- 4834
yjohnson@uga.edu

For questions or problems about your rights please call or write: Chairperson, Institutional Review Board, University of Georgia, 629 Boyd Graduate Studies Research Center, Athens, Georgia 30602; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu.

APPENDIX D

Overview of Co-generative "Cogen" Dialogue Sessions

What is co-gen? Cogens are reflective conversations among selected participants. It is a part of a process of critical pedagogy used to identify contradictions that might be changes with the goal of improving the quality of teaching and learning in the classroom.

Who can participate in cogen? Participants can be selected from any of the groups participating in a given field including teachers, students, researchers, administrators, etc. As a general rule, only "insiders" are invited to participate in cogen sessions.

What is the purpose of cogen? It is an opportunity for participants to talk about shared experiences an in the process collaborate to produce shared understandings and outcomes. One of the outcomes from cogen will be an appreciation and understanding of the perspectives of others. At the end of each session, participants strive to answer the following question: "What did we cogenerate today?"

Rules for Productive Cogen Sessions

1. All participants have equal power within the cogen session.
2. Participants are encouraged and expected to speak freely, as long as dialogue is respectful, caring, and relevant to the discussion topic.
3. Cogenerative dialogue session should be productive and solution-oriented, it is not an opportunity to "vent" or assign blame to others.
4. There is a responsibility to share turns and amount of talking time allotted to each participant; silent or quiet participants should be invited to participate in discussion.
5. It is important to ensure that dialogue does not move onto a new topic until the current topic has been resolved, "What did we cogenerate today?
6. Participants share a responsibility to collectively act in accordance with group consensus on discussion topic.

APPENDIX E

Co-generative Dialogue Session #1 Agenda

I. Welcome

  a. Introduction

II. Overview of Co-generative "Cogen" Dialogue Sessions

  a. What is cogen?

  b. Who can participate in cogen?

  c. What is the purpose of cogen?

  d. Rules for productive cogen sessions

III. Icebreaker

IV. Co-generative Dialogue Session

  a. What are the major issues or concerns related to the CHEM 1211 course?

  b. To what extent are the instructors and administrators aware of these issues?

  c. What resources are currently in place to address these challenges associated with the course?

  d. Are there any unique challenges faced by African American females?

V. Closing: What did we cogenerate today?

Action Items:

Next Session:

APPENDIX F

Interview Protocol: Initial Interview

Research Question	Question	Rationale
What "stories" emerge from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution?	What town or city and state did you grow up in? Describe the place you called "home" during your high school years? Describe the type of high school you attended. Give me a description of the demographics of the high school, i.e. class size, student population, teacher population. Think back to when you were in high school. What was that experience like for you? How would you describe your trajectory into or interest in a STEM major? Describe some pivotal issues and experiences that influence your decision to pursue a degree in science. Now, I want you think about your experience in freshman chemistry. What is this experience like for you?	To find out more about different academic environments that the students has experienced. To understand the level of student interest or investment in a STEM major/career. To learn more about experience in CHEM 1211
What issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution?	How would you describe yourself as a student? Would you consider yourself a successful student in science? How did you prepare or study for your chemistry exams? Do you study with others or by yourself? What were your grades on the 1st and 2nd CHEM 12ll exams?	To learn more about the personality straits and academic behaviors of the student. To determine what sort of support network was available.
What solutions are cogenerated by African American female undergraduate STEM students	What strategies or resources did you seek to help you with your chemistry content? How helpful were the	To assess student understanding of the academic interventions available for this course and to learn which ones

during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution?	academic interventions you utilized? What will you do to differently to prepare for future tests?	are most helpful.

APPENDIX G

Photo- Elicitation: Instructions to Participants

For the interview session, the focus will on learning more about "who you are" as an individual and how you have personally been shaped by your experiences in the freshman chemistry course at the University of Georgia. In addition to open ended questions, we will also use a photo-elicitation method. For this portion of the interview, you will be asked to provide 2-4 photos. The photos may be in any form – self-portraits, graphic images, clips from magazines, computer generated images, celebrities, etc. There are no right or wrong pictures, but please do not provide images of friends, relatives, or associates.

For this next interview:

1. Identify a total of 2-4 photos
    a. Select 1-2 photos that represent **how you see yourself** as an individual and/or as a STEM student.
    b. Select 1-2 photos that represent **how you are perceived by others** as an individual and/or as a STEM student.
2. Submit the photos to me using one of the following options:
    a. Email your pictures to (project email) no later than (date). In the subject line include your name (Last name, First name) and date (mm/ddd/yy). (Note: the photos will be on a password protected system)
    b. Place photos is envelope provided and submit them in person during at the final cogenerative dialogue sessions.

APPENDIX H

Interview Protocol: Final Cogen Session

Research Question	Interview Question(s)	Rationale
Photo Elicitation Instructions: #1: Select 1-2 photos that represent who you are as an individual and/or as a STEM student. #2: Select 1-2 photos that represent how you are perceived by others as an individual and/or as a STEM student.	Explain the process used to search for and select your photo. What does this photo represent (about you, your background, your career aspirations)? How would you title each photo? Are there parallels or conflicts between the sets of photos? Is there a difference between the images? Why or why not? Would you have selected different pictures at the start of the semester? Why or why not? In what ways are you the same? How are you different?	Black Feminist Thought
What issues or concerns are introduced by African American females during co-generative dialogue sessions related to the freshman chemistry course at a predominantly White institution?	Are there any issues or concerns related to the course that were not raised in the co-generative dialogue session? How did your participation impact your experience in Chem 1211?	

What “stories” emerge from co-generative dialogues of African American female undergraduate STEM students about their experiences in the freshman chemistry course at a predominantly White institution?	When you reflect on this semester, what is your most memorable or defining experience in the chemistry course?	
What solutions are cogenerated by African American female undergraduate STEM students during these dialogues about how to improve the quality of teaching and learning in the freshman chemistry course at a predominantly White institution?	What was your final grade in the course? How do you feel about your performance in the course? What advice might you offer to another African American female student about Chem 1211?	