8-2021

Examining the Use of Culturally Relevant Pedagogy in Undergraduate Mathematics Learning Modules with Students of Color

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EXAMINING THE USE OF CULTURALLY RELEVANT PEDAGOGY IN UNDERGRADUATE MATHEMATICS LEARNING MODULES WITH STUDENTS OF COLOR

by

Thomas A. Mgonja

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

In

Education
(Mathematics Education and Leadership)

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UTAH STATE UNIVERSITY
Logan, Utah

2021

ABSTRACT

Examining the Use of Culturally Relevant Pedagogy in Undergraduate Mathematics

Learning Modules with Students of Color

by

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Utah State University, 2021

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In mathematics, Students of Color have persistently performed lower than their White counterparts, thus creating a need to explore instructional methods that could reduce performance disparities. This study investigated culturally relevant pedagogy (CRP) to understand how it might support students' mathematics learning in undergraduate mathematics learning modules. The overarching research question focused on how CRP in undergraduate mathematics Learning Modules supported students' mathematics learning. There were also two main questions that focused on participants' evaluations of the CRP modules and how those evaluations were reported based on subgroups (Students of Color and White). The researcher employed a sequential explanatory mixed-methods design where quantitative and qualitative analysis examined participants' performance and evaluations of the modules, respectively.

After experiencing the modules, most participants demonstrated performance gains, however, Students of Color outperformed White participants. Participants identified the presence of culture, real-world examples, safe and positive student to student interactions, learning aids rooted in real data, and the development of critical consciousness as the most effective aspects of the CRP modules. Students of Color were more likely than White participants to discuss elevated feelings of motivation and engagement, feelings of being listened to and included in the learning process, a connection to the instructor through similar perspectives, and reduced fears of being judged. White participants were more likely than Students of Color to discuss the high quality of the instructor's skills and that they learned from their interactions with Students of Color. White participants had a higher curiosity (than Students of Color) toward better understanding the social issues presented in the CRP modules. Regardless of race/ethnicity, all participants preferred learning mathematics with the CRP modules over traditional methods.

Based on these results, the researcher recommends the use of real-world examples that are culturally relevant, current, and genuinely provoke students to interrogate social issues through mathematics. He also recommends that, in CRP, educators must participate like students, allow independent thought, and be culturally competent in order to develop positive relationships with Students of Color. These results are important because they demonstrate how CRP can be implemented and that Students of Color can excel in mathematics.

(201 pages)

PUBLIC ABSTRACT

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ACKNOWLEDGMENTS

I have been fortunate to be involved with incredible people during this journey. It is incumbent upon me to recognize these giants and I must begin with my supervisors, Dr. Patricia Moyer-Packenham and Dr. Sherry Marx. These two professors have been pivotal in the successful completion of this dissertation study. They have provided invaluable advice, patience, and continuous support during the highs and lows of the doctoral program. Their great knowledge and experience have encouraged me in my academic research and everyday life. To the rest of the committee members, Drs. Beth MacDonald, Jessica Shumway, and Kady Schneiter, thank you for the support and your commitment to serve as a gateway rather than gatekeepers of this Ph.D. I would also like to mention the Office of Research and Graduate Studies for awarding me the Martin Luther King Fellowship Award. This award alleviated the financial stresses of pursuing a PhD and allowed me to focus on learning.

To my wife, Lora Mgonja, thank you for not complaining when I was spending a lot of time away from the family. Your remarkable understanding and encouragement for the past several years made it possible to pursue this PhD. To my mother, Dr. Mary Mgonja, and my colleagues, Dr. Kuo-Liang Chang and Dr. Hazel McKenna, I appreciate you for planting the seed and pushing me to complete this PhD. Last, I would like to recognize Jenny Nehring, a cohort member and a good friend. We have been through a lot during the doctoral program, but we stuck together and inspired each other. It would not have been possible for me to complete this Ph.D. if you were not coming along with me. Like Frodo Baggins and Samwise Gamgee, we began and completed this journey.

Thomas Andrew Mgonja

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CHAPTER I

INTRODUCTION

Background and Problem Statement

Over the past 20 years, many studies have reported a mathematics performance disparity between Students of Color and their White counterparts. Researchers acknowledge several factors that contribute to the cause of this disparity, including racial discrimination from teachers (e.g., Alfaro, Umaña-Taylor, Gonzales-Backen, Bámaca, & Zeiders, 2009; Eccles, Wong, & Peck, 2006; Levy, Heissel, Richeson, & Adam, 2016; Neblett, Philip, Cogburn, & Sellers, 2006; Pascoe & Richman, 2009; Stone & Han, 2005; Taylor, Wright, & Porter, 1994; Wong, Eccles, & Sameroff, 2003), curricula (Hursh, 2007), resources and peers (Williams, 2011), the socioeconomic status (SES) of parents (Lee & Bowen 2006; Matthews, 1984), and the cultural values that the students hold (e.g., Ogbu, 1987).

The National Assessment of Educational Progress (NAEP) reports changes in mathematics achievement levels over time. The NAEP reports the Black-White performance disparity in mathematics generally narrowed from 1970 to the late 1980s (Grissmer, Flanagan, Williamson, 1998; Hedges & Nowell, 1998, 1999; Neal, 2006). The disparity expanded in the 1990s, then steadily decreased through 2004 (Barton & Coley, 2010). Barton and Coley specified that the NAEP Black-White disparity was 40 points (out of 500 available points) in 1973, but in 2004 the disparity dropped to 27 points. The following year (2005), the disparity between Black and White students on the NAEP 12th grade mathematics exam was 30-points (19%). The 30-point difference remained constant through 2015 (Kena et al., 2015). While the lag in mathematics performance is greater for Black students, American Indian/Alaskan Native and Latinx students also lag behind White students by 22 points (14%) and 21 points (13%), respectively. It was also detailed in the 2015 NAEP report that only 10% of American Indian/Alaskan Native, 12% of Latin*x*, and 7% of Black twelfth-grade students scored at or above proficiency levels in mathematics, while 32% of their White counterparts reached the same levels.

The persistent difference in performance is similarly seen on the Scholastic Aptitude Test (SAT). Figure 1 displays the SAT performance disparities from 1986-87 to 2015-16 and the trend shows that the disparities are not narrowing. Actually, the 103-point (25%) White-Black difference in 1986-87 continued through 2015-16 where the difference was 108 points (25%). Furthermore, the 2017 SAT report revealed that only 34% of Pacific Islanders (when not included with Asians), 33% of Latin*x*, 29% of

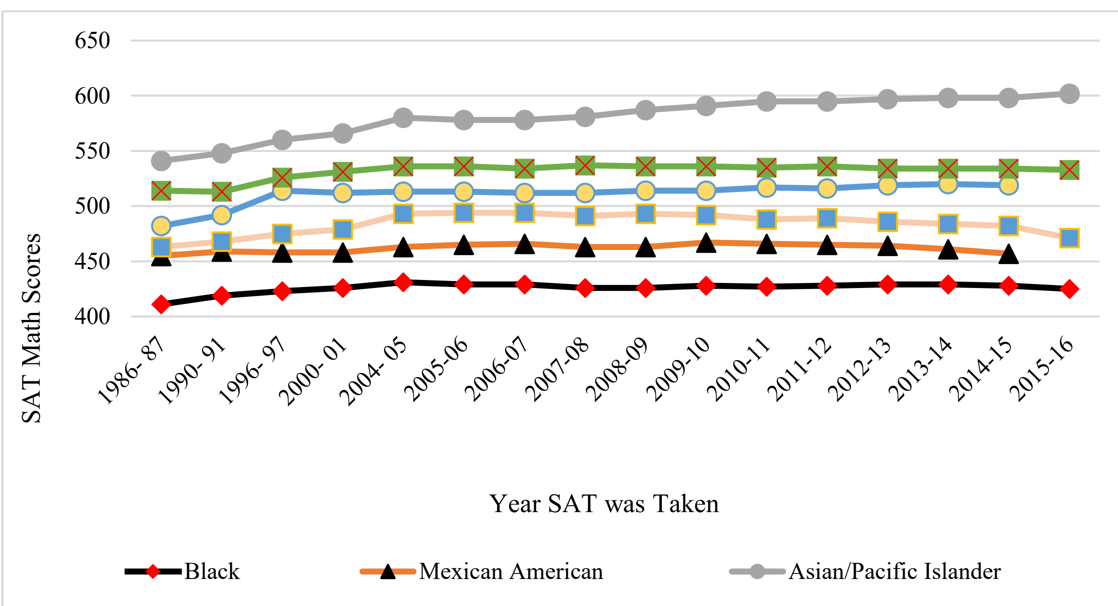

Figure 1. From 1986-87 to 2015-16 mean SAT Mathematics scores based on race/ethnicity (Snyder, de Brey, & Dillow, 2016).

American Indian, and 22% of Black students scored at the mathematics college and career readiness benchmark (530 points, College Board, 2017). This is significantly lower than the 61% of White students who reached that benchmark.

The same concerns can be observed for the American College Testing (ACT) readiness benchmarks in mathematics, where only 41% of ACT-tested high school students in 2016 were prepared for college with respect to mathematics. The lack of mathematical preparation was highly determined by race: 50% of Whites, 13% of Blacks, 27% of Hispanics, 29% of Pacific Islanders, 18% of American Indians, and 70% of Asians scored at or above the college readiness benchmark (ACT, 2016).

Many studies have investigated methods to close the disparities among different sub-groups of students. Policies have encouraged schools to support mathematics learning for all students. For example, the No Child Left Behind Act (NCLBA) was one attempt to promote educational success and address the racial/ethnic performance disparities. The irony of the slogan was that many children were left behind. Darling-Hammond (2007) explained that the initiative provoked unintended negative consequences such as a narrow curriculum, inappropriate assessments of special needs students and English language learners, and incentives to exclude low performing students in order to achieve test score targets for schools. Whatever methods have been used, disparities in mathematics performance continue to exist between Students of Color and White students.

Significance of the Study

One of the causes identified for the disparity between Students of Color and White students includes the enacted curricula (Hursh, 2007). The mathematics curriculum is mostly based on White perspectives and this can affect Students of Color's mathematics performance (Battey & Leyva, 2016). Culturally Relevant Pedagogy (CRP) seeks to integrate and reflect students' interests, cultures, and backgrounds within the mathematics curriculum. This study explored the potential of CRP in reducing mathematics performance disparities based on race.

Competency in mathematics is critical for Students of Color to graduate from high school and be admitted to college. Plunk, Tate, Bierut, and Grucza (2014) found that Black and Latin*x* students were dropping out of high school at over twice the rate of White students as mathematics course requirements increased. Moreover, mathematics plays a vital role in social stratification and economic advantages (Apple & Beane, 1995; Gutstein, 2003). Data analysis, statistics, algebra, and multi-step problem solving can all be useful for citizenship and especially in making financial decisions. Yet, Students of Color traditionally have not had equal opportunity nor encouragement in mathematics (Wiest, 2002). Mathematics achievement is not only essential for careers in science, technology, engineering, and mathematics (STEM) fields, it is important for individual and business success (Barnett, Ziegler, & Byleen, 2014). Many of the current fastest-growing, well-paying professions need at least some postsecondary education (Carnevale, Smith, & Strohl, 2010; Hout, 2012). Inability to complete college leads to lower wages, fewer job opportunities, and a higher likelihood of being unemployed or underemployed relative to students who graduate from college (Kochhar & Fry, 2014). Mathematics is required to earn most college degrees, some mathematics courses are prerequisites to courses required for certain degrees, and higher-level mathematics courses are required for STEM degrees.

Many U.S. students attend college after high school, however, many of them are underprepared for college-level mathematics. This under preparation significantly reduces college graduation rates (Chen, 2016). Chen elaborates that a high number of incoming college students are referred to developmental (remedial) mathematics courses. When students take developmental mathematics courses, this increases “students’ time to degree attainment and decreases their likelihood of completion” (King et al., 2017, p. 7). For all these reasons, it is critically important to explore potential solutions for reducing the disparities in mathematics performance for different ethnic groups of students. This study investigates CRP as one of those potential solutions.

Positionality

I, the researcher, have been teaching developmental mathematics, college-level mathematics, and statistics courses for eight years. I am tenured, 34 years of age, I identify as Black, and my career has mostly been in predominantly White institutions (PWIs) in Florida and Utah. In my teaching career, I noticed the scarcity of Students of Color in mathematics courses, and those that were in the courses lacked competency and confidence. Certain events inside and outside my classes intrigued me to want to investigate Students of Color’s participation in mathematics. My White colleagues made some observations as well. For example, they often wondered why Students of Color frequented my office and not theirs. The Students of Color were also recommending my courses to other Students of Color. Most of these students, including White students, could not explain with clarity why they were recommending my courses. The students' explanation often relied on examples.

Some students said it was my use of rap lyrics in mathematics problems; others referred to a time I used fictitious data and probabilities to predict who would die next in Game of Thrones. One Latin*x* student wrote on the Students' Response to Instruction (SRI) /review: "I know he gets it. I could not afford textbooks earlier in the semester…he was the only instructor I felt comfortable to tell." One Black student recalled a time I called her parents' house to ask why she missed class. These gestures were not an organized instructional method that the researcher planned in order to reach Students of Color. At times I was very traditional by using direct instruction and sometimes I was unorthodox by using techniques that were appreciated by both White students and Students of Color. Several Students of Color took the interactions beyond the classroom. They would stop by my office to "hang" and listen to music while they waited for their next class. There were also instances were Black students asked me to be their mentor and guide them, even beyond my mathematics courses.

However, not all students liked my teaching methods. A White female student wrote on her review of my class that "sometimes the instructor got into his ghetto math." It was at this moment that I started to understand that some students believed there was "real" mathematics and the mathematics of the "others." More importantly, the legitimacy of my mathematics was devalued as it was dubbed “ghetto.” Among many ways to explain these events, I recognized that culture, and how it unfolds in mathematics classrooms, could be a possible explanation. Additionally, I wondered if there was an instructional method that could provide consistency in engaging and improving the learning experiences and performance of all students in mathematics. This was always the lens to which I approached my doctoral courses until I discovered Culturally Relevant Pedagogy (CRP).

Research Questions

The purpose of this study was to explore the use of CRP in an undergraduate mathematics course as a way to address disparities in mathematics learning. The researcher designed three undergraduate mathematics Learning Modules that leveraged the promising features of CRP and that included intermediate algebra topics found in the ACT. The researcher gathered data on students’ performance and opinions about the use of the Learning Modules.

The overarching research question in this study was: How does the use of CRP in undergraduate mathematics Learning Modules support students’ mathematics learning? The following research questions were the focus of the study.

1. How do participants’ mathematics performance scores change after using CRP mathematics Learning Modules and how does that change appear among subgroups (Students of Color and White)?
2. How do participants evaluate the general aspects of the Learning Modules in terms of the quality of the modules for mathematics learning? Are there evaluation patterns based on the two subgroups of participants (Students of Color and White)?

3. How do the participants perceive that the elements within each Learning Module directly supported or hindered their individual learning? Are there perceived patterns based on the two subgroups of participants (Students of Color and White)?

Summary of the Research Design

The study applied a sequential explanatory mixed-methods research design (Creswell & Plano Clark, 2011; Luck, Jackson, & Usher, 2006; Tashakkori & Teddlie 1998). The researcher collected quantitative data then qualitative data in two consecutive phases to explore and explain the use of three mathematics Learning Modules. The study had a total of 19 participants (9 Students of Color and 10 White students) that learned three mathematics topics using the Learning Modules. The Learning Modules were designed using the guidelines of CRP. The data sources used in this study were: a pretest, a posttest, a questionnaire, and individual interviews. Quantitative data were analyzed using descriptive statistics, while qualitative data were analyzed using attribute and structural coding (Saldaña, 2016). Last, quantitative and qualitative data were merged to summarize the results.

CHAPTER II

LITERATURE REVIEW

The purpose of this study was to explore the use of CRP in an undergraduate mathematics course as a way to address disparities in mathematics learning. Prior to 1954's Brown v. Board of Education case, educational needs, together with cultural factors of diverse students, were irrelevant to White educators (Schmeichel, 2012). In order to understand the emergence of CRP, it is vital to understand U.S. schooling practices before and after segregation eras. This chapter starts with a historical context of Students of Color in the educational system. Next the chapter discusses Whiteness and its resulting barriers for Students of Color in mathematics. The next section includes information on the potential of CRP in the Learning Modules as a way to have a positive influence on mathematics learning for Students of Color. The final section brings together these important ideas to present the conceptual framework.

History of Inequitable Opportunities for Students of Color in the Educational System

The U.S. possesses a legacy of educational inequities that were intended to restrict people from receiving quality education based on race, class, and gender. Growing attention has been placed on these inequities especially those based on race (Ladson-Billings, 2006). This section briefly discusses the historical background of American Indians, and then more emphasis will be placed on Latin*x* and Black communities. The latter two groups are emphasized in the discussion because they are the biggest ethnic minority groups in the U.S. and in the locale of the study.

American Indians' Background in Education

American Indians, also referred to as Native Americans, are among those that experienced inequities in educational opportunities. Indians were first introduced to mission schools with the purpose of converting them and exploiting their labor so as to advance the church (Beyer, 2014). Later, in the 1870s, boarding schools were established for Indians and the phrase "kill the Indian in order to save the man" (Pal, 2017, p. 201) truly represented the purpose of these schools. Indians were never exposed to full mathematics courses, only basic arithmetic, reading, English, writing, Greek, Latin, and a manual labor program that made them work around school grounds (Meza, 2015). Up to the mid-1900s, Indians' attendance at boarding schools was mandated. The schools were an attempt to impose assimilation of Indians into the "White" world, but it created a people that belonged nowhere (Lesiak, 1992). The Indians neither fitted in the reservations nor the stratified mainstream. Ladson-Billings (2006) details that the predominately White colleges did not welcome the Indians that graduated from the boarding schools. She continues that "only historically Black Colleges, such as Hampton Institute, opened their doors to them. There, the Indians studied vocational and trade curricula" (p. 5). Consequently, several preceding generations of today's American Indian students are without professionals, like lawyers, bankers, or doctors to emulate. What we encounter today are first or second generation of American Indian professionals, not because of academic indifference or cultural inferiority, but because of the absence of an honorable humane system of education.

Latin*x*'s Background in Education

The term "Hispanic" or "Latin*x*" refers to a person of Dominican, Cuban, Mexican, Puerto Rican, South or Central American, or other Spanish culture or origin regardless of race (U.S. Census Bureau, 2010, p. 2). The history of Latin*x* people's fight for equality in the U.S. is often forgotten. Anti- Latin*x* prejudice, such as school segregation, illegal deportation, and even lynching, were common since the 1840s (Blakemore, 2017). In fact, prejudice against Latin*x* people mostly begins in 1848, as the U.S. won the Mexican-American War. The war's end was marked with The Treaty of Guadalupe-Hidalgo which granted 55% of Mexican territory, including a significant number of its Mexican inhabitants, to the U.S. Laura Gómez (2007), a legal scholar, explains

> …naturalization of Mexican citizens under the Treaty…suggested Mexicans had white status given that…naturalization was limited to white persons. Thus, Mexicans' collective naturalization in 1848 prompted a *legal* definition of Mexicans as "white." (p. 83)

In truth, Mexicans were never White in the eyes of White Americans and their naturalization threatened the ways of the already established "White"/Anglo-Protestant America. The Anglo Protestants feared "race suicide" triggered by the incoming wave of "different" people (Gutiérrez, 1995). U.S. schools served to protect the status quo by deculturizing and limiting Mexicans' education, therefore restricting them from political and economic advancement (Nieto-Phillips, 2008). Thus, anti-immigrant views initiated and increased the segregation of Mexican-Americans from White public schools (Gutiérrez, 1995). Initially, Mexican-American schools were only established in rural ranches to serve children of Spanish speaking laborers. However, the schools later spread to the cities. In general, Latin*x* students attended highly unequipped schools that were without basic supplies and sufficient teachers (Blakemore, 2017). English language deficiencies were often used to defend segregation even though most Latin*x* students spoke English (MacDonald, 2013). Caucasian parents did not want their children schooling with "dirty and diseased" Mexicans (Miguel, 1987). Where African Americans of the South learned under strict de jure school segregation according to race, Mexican American students were put in Mexican schools as a result of the "color of law" or "custom" (Montejano, 1987).

By the 1940s, 80% of the Latin*x* children in areas like Orange County, California went to separate schools (Blakemore, 2017). Such schools continued to be dilapidated facilities that lacked basic supplies and adequate teachers (Blakemore, 2017). Most of these schools only offered vocational classes and did not have a complete 12 years of instruction (Moll, 2010). Complexion and last name were often the factors used for assigning children to these schools. Among the children that attended these schools was Sylvia Mendez, a young girl whose parents challenged the racial segregation in Orange County, California. The 1946 *Mendez v. Westminster School District of Orange County* was influential in repealing several segregationist provisions of California law. The ruling by Judge Paul J. McCormick was that the "segregation prevalent in the defendant school districts foster antagonisms in the children and suggest inferiority among them where none exists" (Johnston, 2011, p. 210) plus the equal protection clause was violated. In 1954, Hernandez v. Texas also established that the equal protection provided by the 14th Amendment of the U.S. Constitution did not just cover Black and White Americans but covered all racial groups.

Despite *Mendez*'s ruling, segregation of Latin*x* students from White schools continued. This was achieved by a technicality that Latin*x* people are considered White for desegregation purposes. Contreras and Valverde (1994) explain that "post-*Brown* generation saw desegregation of predominately African American school settings with Latin[*x*] students while White students continued to be assigned to all-White schools" (p. 471). Thus, by pairing Black and Latin*x* students while excluding White students, Students of Color continued to be learning under inferior conditions. The technical loophole continued to exist until *Cisneros v. Corpus Christi Independent School District* (1970). In *Cisneros*, it was the first time that a court declared Mexican American as an ethnic minority group for intentions of desegregating public schools. However, the segregation of Latinx people were not officially noted until *Keyes v. School District No. 1, Denver, Colorado* where the court held that Black and Latin*x* students suffer similar prejudiced treatment when likened to White students. A publication by the U.S. Commission of Civil Rights (1967) was used support the ruling and it was at this point that Latin*x* students were included in the academic disparities between White and Black.

Blacks' Background in Education

Black people in America have been slaves longer (216 years) than they have been free (155 years). Once they were emancipated in 1865, the Freedman's Bureau and some state legislatures pushed to educate the former slaves. Prior to emancipation, various Southern laws, like the one passed by Mississippi legislation in 1831, banned African Americans from learning, reading, and writing (Beyer, 2014; Rucker & Jubilee, 2007).

Education had to be covert and only few, like an African American woman named Mary Peake, dared to teach many physically enslaved African Americans how to read and write under an oak tree in Hampton, Virginia (Cobb, 2014). After emancipation, the schooling of Black people was to be done separately from Caucasians, which later sparked a series of legal cases to fight for desegregation. The first one was *Plessy v. Ferguson* (1896), which concluded that schooling between White and Black students could remain "separate" provided the distribution of resources and access was equal. The second was *Cumming v. Richmond County Board of Education* (1899), where the Supreme Court ruled that there is no "clear and unmistakable disregard of rights" when only Black students are refused schooling based on race. The third was *Gong Lum v. Rice* (1927), where the ruling meant that a Chinese student, Martha Lum, was not being refused "equal protection" by being categorized as "colored" and being required to attend Black schools instead of White schools.

Black people were fighting for desegregation of schools because schools were far from equal. There was an unequal distribution of resources to the schools. For example, South Carolina's Greenwood County was spending $6.29 per White student and $0.23 per Black student in 1901 (Chesnutt & Rogers, 1991). Furthermore, in 1941, 19 counties in South Carolina did not have high schools for Black students and the entire state only had eight school buses allocated for Black schools (Chesnutt & Rogers, 1991). In 1945 in Mississippi, one room schoolhouses with one teacher were common for Black schools. In addition, 54% of White teachers had a college degree, while only 10% of Black school teachers held a college degree. In 1950 in Durham, North Carolina, White schools had

136 pieces of equipment in their science laboratories while 21 pieces of laboratory equipment were present in Black schools. Furthermore, a standard school year for Black students in rural areas of the South was four months. It was not until 1968 that Black students in the South experienced universal schooling (Anderson, 1978). Similar inequities were present in the northern states where they practiced de facto segregation through housing patterns (Tatum, 2008). Thus, White children in White neighborhoods subsequently attended White schools in northern states. In 1954, the fight for desegregation reached a climax with the monumental court case of *Brown v. The Board of Education* where it was ruled that “separate” was fundamentally “unequal.” However, it was not until 1964, with the passage of the Civil Rights Act, that much of the old segregation began to change.

For desegregation to be achieved, many of the students living in racially segregated communities had to be transported to White communities. Busing came as a solution, but by the late 1970s, many Black parents began to disapprove of busing and were wary as their neighborhood schools worsened or closed. One unintended consequence of desegregation was that it ended the teaching careers of many Black teachers. From the 1950s to 1960s, White communities preferred White teachers more than Black teachers (Walker, 1996). Walker explains that the unique culture of Black teaching died with *Brown*. The presence of Black teachers ever since the Civil Rights Movement became a rarity in public schools (Toppo & Nichols, 2017) and with the loss of Black teachers, Black institutions were also decimated. Black communities envisioned desegregation as a two-way street and not a process that would dismantle their neighborhood schools. In addition, integration did not stop their children from being discriminated against by White teachers and peers. Antipathy towards busing grew until the 1990s and became a community-based movement that advocated for the abandonment of desegregation in order for Black neighborhood schools to survive.

Today, there is still segregation and disproportional allocation of resources, especially in schools with high numbers of Students of Color. “Almost 40 percent of black and Hispanic students attend schools where more than 90 percent of students are nonwhite. The average white student attends a school where 77 percent of his or her peers are also white” (Spatig-Amerikaner, 2012, p. 1). This suggests that schools today are still patently segregated as they were in 1960s. Mosenkis’ (2014) report is an example of the disproportional allocation of resources in Philadelphia school districts. The districts that had higher numbers of Students of Color received significantly less funding than schools with more White students. In addition, Mosenkis’ results demonstrated that, the more Students of Color a district has, the less funding they received. At the national level, schools annually spend $334 more per White student than per non-White student (Spatig-Amerikaner, 2012).

Conclusion

In 1751, Benjamin Franklin wrote,

> …why should we…darken [America’s] people? Why increase the sons of Africa, by planting them in America, where we have so fair an opportunity, by excluding all blacks and tawneys, of increasing the lovely white? (Franklin, 1918, p. 224)

These words reflect the founding father’s vision of who should inherit America. If one assumes that education is the key to inheriting America, then providing high quality education to sons of Africa and tawnies would taint Franklin's, or perhaps America's, vision. All of the educational inequities, through segregation laws, policies, disproportional funding, and other racist laws and practices, have always been rooted in preserving America for the White. How then can one be surprised by the academic underachievement of Students of Color?

Marx and Larson (2012) explain that "Contemporary educational inequities grow out of these early injustices but are also augmented by present-day biases and systemic inadequacies that characterize everyday schooling…" (p. 261). Orfield and Lee (2005) agree with this and identify segregated schools with less human and financial resources as the main reason for the underachievement of Students of Color. For these reasons, this study and recent scholars find it is more appropriate to refer to the situation as an *access* or *opportunity gap,* than the popular term *achievement gap* (e.g., Pitre, 2014). The new term emphasizes the root of the problem—educational inequities. It is also important to note that Students of Color in college today are not more than three generations removed from an era where their parents were denied access to high quality education. Because a parent's level or quality of education is a predictor of a child's academic achievement (Davis-Kean, 2005; Dubow, Boxer, & Huesmann, 2009), then America's reprehensible past may be the chief instigator of the current racial academic disparities.

Whiteness and its Resulting Barriers for Students of Color in Mathematics

This section uses Whiteness to critique mathematics education and how Students of Color are affected by it. “Whiteness can be defined as a system of privilege based on race whereby White ideology is viewed as a reference point from which all other identities are compared” (Fine, Weis, & Pruitt, 2004 p. 856). Thus, identities such as Native American, Latin*x*, and Black are perceived as society’s multicultural subcultures in the presence of Whiteness. Leonardo (2009) elaborates that “Whiteness is not a culture but a social concept” (Leonardo, 2009, p. 170). This does not imply that White people do not have a culture. Ice hockey, ballet, hamburgers, and fries are examples of White cultural practices that even non-White people partake in, though such practices are not indigenous to them. Leonardo continues that Whiteness is often invisible but more recognizable by people of color. For example, people of color easily recognized and protested the Caucasian color of band-aids, however, Whites may have assumed that color to be standard. It is within such standardizations that Whiteness uses a “colorblind” consciousness to suppress the discourse on race, and therefore normalize White experiences (Bonilla-Silva, 2003; Fine et al., 2007). By not acknowledging race, the colorblind perspective un/intentionally undermines students’ unique experiences across race lines. Just like the protest “All Lives Matter” undermines “Black Lives Matter” (Carney, 2016), the perpetuation of cultural neutrality/color-blindness undermines the call for multicultural education. To be specific, one cannot claim “it is not about color” when people of color are mostly affected.

Furthermore, White students’ supremacy in educational achievement can be viewed as a subset of Whiteness, where racial hierarchies are legitimized. For instance, reports on mathematics achievement show Asian American students outscoring White students, however, society refrains from pathologizing White's underachievement (Martin, 2009). However, when White students outperform students of color, then Whiteness or the colorblind racial ideology would support explanations for presenting the performance as "gaps." It is important to understand the role that Whiteness plays in mathematics learning experiences for Students of Color, especially as White methods of knowing are viewed as natural and they dominate other's ways of knowing. Specifically, how does Whiteness influence the interactions, expectations, and kinds of experiences that teachers and students have in mathematics? The discussion covers the connection of Whiteness to deficit perspectives, to mathematics curriculum, and to teacher education.

Whiteness and the Occurrence of Deficit Perspectives

Battey and Leyva (2016) contend that colorblind ideologies and practices relegate Students of Color and limit their positive development of racial and mathematics identities. By perceiving Students of Color as incapable, Whites end up receiving unquestionable legitimacy in educational spaces (W. L. Moore, 2008). In mathematics education, notions of incapability are observed in racialized hierarchies of mathematical ability that position Students of Color at the bottom and cause them to question their identities as doers of mathematics. Such deficit perspectives are associated with disidentification with mathematics, lower-quality instructional experiences, and poor relationships with teachers (Oppland-Cordell, 2014; Spencer, 2009). Tracking, referral to remedial/developmental programs, and labelling students as "at risk" are living examples of racialized hierarchies of mathematical ability that frame students' identities (Lewis, 2004). Tracking, particularly, is ineffective (Burris & Welner, 2005) and Students of Color are highly populated in the lower tracks, while the higher tracks are mostly composed of White students (Chambers, Huggins, Locke, & Fowler, 2014; Tyson, 2011). One could argue that segregation is at play and the worst part is that it appears as standard/normal. Rather than tracking, many scholars have investigated the academic effects of detracking and found it to significantly improve mathematics performance for Students of Color (e.g., Condron, Tope, Steidl, & Freeman, 2013). This is especially true when detracking is combined with academic support such as after school classes (Condron et al., 2013).

Another manifestation of deficit perspective is teachers holding low expectations of Students of Color (e.g., Pringle, Lyons, & Booker, 2010). Such teachers often blame racial minorities' families and communities for low academic performance (Lynn, Bacon, Totten, Bridges, & Jennings, 2010). Teachers can send overt messages by commenting that a particular group of students requires "basics" (Battey & Franke, 2015). Overt messages of low expectations can also be sent to high performing Students of Color. Battey and Leyva provide an example that a high performing Black student attending a calculus course can be questioned by a White peer whether they are at the right place. Students internalize these messages to form their mathematical identities. Several studies show that holding high expectations in Students of Color has been documented to improve performance (e.g., Corbett, Williams, & Wilson, 2005; Gollnick & Chinn, 2009; Johnson, 2009; Moses-Snipes & Snipes 2005; Nieto & Bode, 2008). Blanchard and Muller (2015) explain that "…teachers' perceptions of hard work help nearly all students to get ahead and on to more demanding math classes" (p. 273). Whether it is tracking or low expectations, the colorblind ideology, which is embraced by Whiteness, constructs the meaning of being "good" in mathematics and positions students across a continuum of mathematics ability.

The mathematical delegitimization of Students of Color also puts them in a position to prove themselves (McGee & Martin, 2011). McGee and Martin call this stereotype management and their analysis found that high performing Black engineering and mathematics students were always mindful that their racial identities were undervalued. The students in their study shifted from proving stereotypes wrong to an internal motivation to attain academic success in White spaces. However, the risk Students of Color face in confirming their assigned relegated position is often referred to as stereotype threat (Steele, 1997). Steele identified racial *stereotype threat* as a factor that can widen performance disparities between Students of Color and their White counterparts. This is also witnessed in mathematics (e.g., Tine & Gotlieb, 2013), but by validating students' cultural identities, the psychological threat from being negatively stereotyped is often reduced (Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski (2009).

Whiteness in Mathematics Curriculum

The historical context discussed earlier showed the exclusion of people of color in curricula, therefore highlighting whose perspective in education matters. To connect history with Whiteness ideologies, "one can examine curricula for presentations of mathematics as neutral or cultureless as well" (Battey & Leyva, 2016, p. 66). Bourdieu

(2003) argued that a White/Eurocentric curriculum had done “double violence”: (1) one culture was imposed on others; (2) the imposition was forgotten. In relation to mathematics, others’ culture in mathematizing was subjugated by White mathematical thinking. Then educational institutions inherited the White mathematics and naturalized it to a point many believe it is the only knowledge worth including in school mathematics curricula. Some scholars argue that even Students of Color believe that the creation and ownership of mathematics belongs to a community other than their own (Barta, Cuch, & Exton, 2012).

This belief, and Students of Color’s experiences in mathematics, has been used to explain the racial disparities in mathematics achievement (Barta, Eglash, & Barkley, 2014). With the domination of Whiteness in mathematics curricula, Students of Color often feel either hypervisible (Higginbotham, 2001) or invisible (Feagin & Sikes, 1994). They feel hypervisible because their population is so low in quantitative subjects, and invisible because their culture, interests, and history are not acknowledged. Hypervisibility in Students of Color may bring about essentialism, tokenism, and the pressure of one student representing the whole race (W. L. Moore, 2008). In mathematics classrooms, hypervisibility of Students of Color would trigger teachers to focus on the students’ behavior while their mathematical thinking continues to be invisible. “Examining both the invisibility and hypervisibility of Students of Color in mathematics spaces with respect to being successful in higher-tracked mathematics courses, for example, shows whiteness systemically acting within educational institutions” (Battey & Leyva, 2016, p. 73).

Role of Teacher Education in Perpetuating Whiteness

Milner, Pearman, and McGee (2013) noted that "the curriculum of teacher education mirrors, in many ways, the P-12 curriculum in that it is Eurocentric and White dominated" (p. 158). In fact, Siwatu (2011) discovered that preservice teachers felt more equipped to teach in suburban schools than in urban schools. He rationalized that a "universal" approach (culturally neutral approach) used in teacher education contributes to preservice teachers' lack of preparedness for urban schools. Whiteness is present in this universal approach because it only develops competent and confident teachers for suburban schools which are "Whiter" in culture and populace (Simon & Johnson, 2015). Siwatu continues that because of the universal approach being extensively used in America, many preservice teachers may not be getting mastery and experience in culturally and linguistically diverse educational settings. For these reasons, traditionally trained teachers find it difficult to connect with their diverse students, which often leads to students participating less and teachers developing misconceptions of student ability, potential, and motivation (Hernandez, Morales, & Shroyer, 2013). The problem is propagated with teacher education programs only requiring one multicultural education course for prospective teachers. Furthermore, a majority (78%) of teacher education faculty are White (Milner et al., 2013) and Sleeter (2016) explains that less diversity in the teacher education faculty results in White interests being more represented in coursework than culturally diverse backgrounds.

Even when teachers gain experience in high racial minority schools, they frequently transfer to schools serving wealthier, "Whiter" student populations (Simon &

Johnson, 2015). It is often the high-quality teachers that tend to leave, and this turnover has been increasing for more than two decades (Ronfeldt, Loeb, & Wyckoff, 2013). Teacher turnover is known to negatively affect mathematics performance in Students of Color (Ronfeldt et al., 2013). Simon and Johnson (2015) discuss a variety of reasons why mathematics teachers migrate to Whiter schools (e.g., better pay or working conditions). Among these reasons is that teacher education programs are not successfully equipping teachers for culturally and linguistically diverse students (Picower, 2009). Picower's study (*The unexamined Whiteness of teaching: How White teachers maintain and enact dominant racial ideologies*) demonstrates how White teachers deny, subvert, or avoid multicultural education in order to maintain their hegemonic understandings. In multicultural education, this is often referred to as resistance. Picower elaborates that fear of people of color based on stereotypes, media representations, and cultural incongruence is one of the methods of resistance. The fear can escalate to terror when a White teacher is alone among people of color, like in a classroom. Picower quotes one White teacher describing a neighboring school with a high number of Black students:

> We always knew that was the high school that was always in trouble. That was the high school that had really big Black football players… I mean my friends in general didn't want to go to their school for sports events because it was a little scary. Scary like their attitude and stuff was different – seemed to be different than ours – and their behaviors and stuff seemed to be different [to] ours, so we avoided it… I think that you are always going to have those feelings. (p. 202)

The perception of different as dangerous highlights that Whiteness is the standard to which safety is measured. In order to mitigate the fleeing of teachers from high racial minority schools, it is important to recruit more culturally and linguistically diverse teachers and embrace a multicultural approach rather than the universal/cultural neutral approach to preparing teachers (Picower, 2009; Sleeter, 2017). Otherwise, Students of Color will continue to have more teachers (than White students) that are novice, have a lateral entry license, have low licensure test scores, are certified but not in mathematics, are not board certified, have no graduate degree, and come from uncompetitive colleges (Clotfelter, Ladd, & Vigdor, 2010). However, "…having a teacher with strong rather than weak credentials would, on average, more than offset the adverse effect of racial and socio-economic differences…" (Clotfelter et al., 2010, p. 34).

Conclusion

This dissertation assumes that mathematics education is not neutral and that it aligns with society's dominant racial ideologies. Using Whiteness as a frame for critiquing mathematics education suggests ways that Students of Color have been academically delegitimized. The delegitimization may cause Students of Color to develop the need to prove themselves, to experience stereotype threats, and to reject or disidentify with mathematics. These issues are known to negatively affect the mathematics performance of Students of Color and so, while hierarchies may be necessary, the virtue of a hierarchy of mathematical competence that is founded on such biases is questionable. That is, when Students of Color's participation in mathematics is delegitimized, then their clumping at the bottom of these hierarchies is not a valid depiction of their mathematical ability and knowledge construction. Furthermore, the presence of biases will continue to ensure that hierarchies are part

> …of larger racialization processes that, on the surface, appear to put forth objective findings but, based on more critical analysis, are designed to maintain racial hierarchies and socially construct African American, Latino, and Native

American students as less. (D. B. Martin, 2009, p. 324)

Many solutions have been proposed to improve the learning experiences of Students of Color in White settings. For example, Egalite, Kisida, and Winters (2015) proposed Caucasian, Black, and Asian/Pacific Island students be taught by race-congruent mathematics teachers. It is true that Race-congruent teachers have positive effects on students' performance (Egalite et al., 2015), but teachers of color can also perpetuate Whiteness (Battey & Leyva, 2016). As part of the many solutions, this study supports two notions: (1) White students' mathematics performance should not be viewed as a ceiling or standard for all to strive for; and (2) Cultural diversity should be embraced in the teaching and learning of mathematics instead of relying on Eurocentric/White curricula. By doing so, then perhaps Students of Color's performance can improve without establishing ceilings.

Potential of Culturally Relevant Pedagogy to Address Educational Barriers

There are numerous methods of connecting mathematics to culture. For example, Barta et al. (2014) show the presence of mathematical concepts in cornrow hair braiding, Mayan culture, the streets of Ouro Preto (Brazil), Navajo beading and weaving patterns, Adinkra symbols, the game of Klappenspiel, graffiti shapes and styles, stick charts and woven fronds, Rangolee and Kolam folk art designs, and the Potawatomi two-sided dice. When culture is present in mathematics it demonstrates to learners that mathematics is not an isolated subject. Additionally, learners may begin to appreciate how mathematics influences culture and how culture can dictate the creation and use of mathematics. Regrettably, the infusion of culture in college mathematics is among the least practiced (A. J. Rodriguez, 2015) and the least studied areas of research (Brown, Boda, Lemmi, & Monroe, 2019). This study concurs with Sleeter's (2012) argument that the use of culture in education should be accompanied by evidenced-based assessments of academic impact and research explaining its positive affective impact. This section presents what has been studied about CRP and it begins by discussing its definitions and constructs, effectiveness of CRP, and why CRP is not generally implemented in mathematics education.

Definitions and Constructs of Culturally Relevant Pedagogy

The term CRP is based in the constructivist paradigm and ontological foundation. Hatch (2002) argues that the constructivist ontology describes knowledge as individualized and founded upon unique perspectives and constructions of diversity, difference, and culture. Howell (2013) expounds that CRP dictates that educators must acknowledge that teaching and learning is socially and culturally constructed and inherently value laden. Additionally, CRP uses the Racial Identity Theory, Critical Theory, and Social Cognitive Theory. These theories together with the constructivist paradigm create the basis to which CRP is established and can be implemented by educators in mathematics (A. Martin, 2016). It is Ladson-Billings (1995) that coined the phrase "culturally relevant pedagogy" (CRP) and popularized it in her article "Toward a Theory of Culturally Relevant Pedagogy." However, CRP has also been referred to as "Culturally Compatible" (Jacob & Jordan, 1987), "Culturally Congruent" (Au &

Kawakami, 1994) and “Culturally Responsive” (Gay, 2018).

Ladson-Billings (1995) describes CRP as a “pedagogy of opposition...committed to collective, not merely individual empowerment” (p. 160). Gay (2018) explains CRP as teaching “to and through [students’] personal and cultural strengths, their intellectual capabilities, and their prior accomplishments” (p. 26); CRP is based on “close interactions among ethnic identity, cultural background, and student achievement” (p. 27). Gay continues, “Students of Color come to school having already mastered many cultural skills and ways of knowing. To the extent that when teaching builds on these capabilities, academic success will result” (p. 213). More recently, Paris (2012) proposed the phrase “culturally sustaining pedagogy” (CSP) and claimed it to be a better phrase than the previous ones. Paris argues that the phrase CSP ensures “the valuing and maintenance of our increasingly multiethnic and multilingual society” (p. 94).

Beyond different phrases, researchers also disagree on how to define CRP. According to Ladson-Billings’ conception of CRP, three criteria must be satisfied: (1) there must be academic success; (2) cultural competence must be developed and preserved; and (3) there must be a critical conscious development through which the current social order can be challenged by students (Ladson-Billings, 1994). In CRP, critical consciousness is defined as “the ability to recognize and analyze systems of inequality and the commitment to take action against these systems” (El-Amin et al., 2017, p. 18). The usage of the phrase CRP is also seen in Brown-Jeffy and Cooper (2011) who leveraged the work of Gay (1994, 2000), Nieto (1999), and Ladson-Billings’ to develop five principles for CRP: “(1) identity and achievement, (2) equity and excellence,

(3) developmental awareness, (4) teaching the whole child, and (5) student-teacher relationships" (p. 71). There are many variations, but these principles highly overlap in meaning. In fact, most scholars agree that CRP is a mindful practice and research-based instructional method that promotes students' racial and cultural identities.

This study uses the phrase CRP over others because it is the most commonly used one and it has been reinterpreted to become broader than how Gloria Ladson-Billings first envisioned it (Brown-Jeffy & Cooper, 2011; Henry, 2017). That said, there are recent studies (e.g., Brown et al., 2019) that still use Ladson-Billings' original version of CRP and its accompanying theory to understand how students' cultural references can be incorporated in pedagogy. The next section also uses theoretical underpinnings of CRP by Ladson-Billings (1992, 2014) to explain three foundational constructs behind CRP. The three constructs are: conception of self and others, conceptions of knowledge, and social relations.

Conception of self and others. Ladson-Billings (1992, 2014) summarizes that culturally relevant teachers: believe that all students can thrive academically, perceive teaching as an art that is unpredictable and ever evolving, perceive themselves as participants of the community, perceive teaching as contributing back to that community, and subscribe to the Freirean idea of teaching as mining. Believing in students' success or holding high expectations for all students is frequently mentioned in CRP studies (e.g., Bonner, 2014). Gay (2018) refers to it as a pedagogy that insists "on high quality performance" (p. 217). To achieve this, some suggest adopting a warm demander pedagogy—"provide a tough-minded, no-nonsense, structured, and disciplined classroom environment for kids whom society had psychologically and physically abandoned" (Irvine & Fraser, 1998, p. 56). Similar to Ladson-Billings (1992), Bonner explains that students need to feel like they can construct, discover, and engage with mathematics. This involves the instructor being willing to give up some power, otherwise, knowledge will simply be transmitted from the instructor. Bonner explains that underserved students, such as Students of Color, "often feel disempowered in the mathematics classroom, largely because of prior experiences" (p. 392). In her observation of culturally relevant classrooms "it was difficult to determine who was driving the lessons (students or teacher) at any point in time" (Bonner, 2014, p. 393).

Social relations. Culturally relevant teachers: support fluid student-teacher relationships, establish a connectedness with all of the students, inspire students to learn collaboratively, establish a community of learners, and incite learners to be responsible for another. Establishing camaraderie between all those involved in the learning process is a key feature of CRP (Hernandez et al., 2013). Wang (2007) and Gay (2018) propose that this can be done by building teamwork into the curriculum and setting clear guidelines of how to make it successful. Ukpokodu (2011) suggests using heteregenous groupings based on race, gender, ability, language, etc. Ukpokodu also suggests infusing democratic values in group work and creating complex tasks with multiple parts to allow each group member's contribution. There must be trust, social networks, and an environment of open exchange, which instructors can establish by serving as facilitors and repositioing themselves as equal to studernts (Wang, 2007). Gay explains that "students perform much better in environments were they feel confortable and valued"

(p. 232). Wang continues that such environments can be created by the instructor positioning herself as a “friend, mentor, model, critic, teacher, and confidante” (p. 218) to her college students. Fostering such relationships with students and supporting their critical consciousness assists with intellectual empowerment (Timmons-Brown & Warner, 2016).

Conception of knowledge. Culturally relevant teachers believe: “knowledge is not static; it is shared, recycled, and constructed; knowledge must be viewed critically, teachers must be passionate about knowledge and learning; teachers must scaffold, or build bridges, to facilitate learning; and assessment must be multifaceted, incorporating multiple forms of excellence” (Ladson-Billings, 1995, p. 481). Many studies show that domain-general learning is facilitated by language, culture, and other socially constructed factors (e.g., Boykin & Allen, 2003; Delpit, 1995; Gay, 2018; Ladson-Billings, 1994, 2001; Nieto, 2012). This includes domain-specific fields, such as mathematics. For instance, Ukpokodu (2011) argues that teachers must realize that mathematical knowledge rests within a group’s sociocultural frame. Thus, it is important to allow students to express their mathematical knowledge in their unique ways especially when these ways can be based on culture. For example, long division in Brazil is performed different than in the U.S., and so a Brazilian student should not have to give up such mathematical strategies in order to assimilate in a U.S. mathematics classroom. Also, teachers should be able to build on what their students already know as they support them to be critical independent thinkers (Hernandez et al., 2013). When teachers contextualize mathematics based on students’ interests, experiences, and communities then the subject can be used as a tool to critique the social order (Martin, Gholson, & Leonard, 2010). This perception also establishes goals for mathematics education that embrace not only high performance for students but also having them use mathematics to develop their identities and to amend the conditions of their lives in emancipatory ways (e.g., Gutstein, 2006). When teachers contextualize mathematics and then scaffold instruction, positive inclusive learning spaces can be created (Klinger & Gonzalez, 2009; Worrell, 2007).

Models of CRP in Mathematics

Though the praxis of CRP in mathematics is minimal, there are varying CRP models that are specific to mathematics. With different models, it implies instructors' use of CRP can also differ (Brown-Jeffy & Cooper, 2011). The two most common models are Culturally Relevant Mathematics Pedagogy (CureMap; Rubel & Chu, 2011) and Culturally Responsive Mathematics Teaching (CRMT; Bonner & Adams, 2012). Table 1 shows the principles of these models. In short, CureMap promotes conceptual understanding and critical consciousness by leveraging student's experiences. CRMT focuses on student-teacher communication, teacher knowledge, and student-teacher relationships and trust as foundations to student learning and academic success. Hernandez et al. (2013) also produced a Culturally Responsive Science and Mathematics Teaching (CRSMT) model. The CRSMT model considers dispositions and instructional techniques that educators can execute to teach mathematics in a culturally responsive manner. The CRSMT model can also be used as an assessment tool for analyzing mathematics instruction and its cultural responsiveness. Consequently, the CRSMT model can be used by educators to assess and reflect on their teaching practices.

Hernandez et al.'s (2013) CRSMT model is governed by five principles: content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development. (Appendix I shows this model.)

Table 1

Models of CRP in Mathematics

Model	Citation	Principles of the model
Culturally Relevant Mathematics Pedagogy (CureMap)	Rubel and Chu (2011)	• Teaching mathematics for understanding • Center instruction on students' experiences • Develop students' critical consciousness with or about mathematics
Culturally Responsive Science and Mathematics Teaching (CRSMT)	Hernandez et al. (2013)	• Content integration • facilitating knowledge • construction • prejudice reduction • social justice • academic development
Culturally Responsive Mathematics Teaching (CRMT)	Bonner and Adams (2012)	• Communication • knowledge trust/relationships • constant reflection/revision

This dissertation study used Hernandez et al.'s (2013) CRSMT model to design the mathematics Learning Modules. The CRSMT model is more comprehensive than other models and it has more clarity and specificity for operationalizing CRP in mathematics. Unlike other models, the CRSMT model adds a prejudice reduction principle and it prescribes "…methods for candidates to use in dealing with injustices when they encounter them in the schools" (Hernandez et al., 2013, p. 818). Clarity in prejudice reduction is important because stereotype threats, microaggressions, and other injustices in classrooms have been shown to influence students' performance (e.g., Alfaro et al., 2009). However, prejudice reduction in the CRSMT model focuses only on native language support, fostering positive student-to-student interactions, and creating a safe learning environment. This study recognizes that there are multiple methods to reduce negative attitudes or perceptions that a student (or instructor) can hold in relation to others who are different. That is, prejudice reduction is more complex than the one proposed by the CRSMT model, but it is a good introduction for discussing the occurrence of injustices in the classroom.

Social justice is another a key element that is often found in scholars' conceptions of CRP. However, Hernandez et al.'s (2013) observation of teachers who use CRP shows that it is "a challenge to find evidence of dispositions or behaviors related to social justice" (p. 815). Social justice is defined as educators' willingness "to act as agents of change" (Villegas & Lucas 2002, p.5), by emboldening their students to challenge the status quo which then supports "the development of sociopolitical or critical consciousness" (Ladson-Billings, 1995, p. 483). One could argue that the purpose of school is to impart knowledge, develop critical consciousness among students, and nurture students to be agents of change themselves. Another could argue that the purpose of school is to preserve the status quo. While this study subscribes to the former notion, the area where the study was conducted leans towards the latter more conservative notion of school. The area is homogeneous in culture, faith, and sometimes in thought. Thus, care was given in what the students challenged during the Learning Modules. The goal is not to create controversy, but to develop these skills for students to be agents of change after exposure to CRP.

Effectiveness of CRP

The infusion of cultural references in mathematics provides teachers with opportunities to improve mathematics curriculum socially, politically, culturally, and academically for students while assisting educators in addressing various student needs (Sampson & Garrison-Wade, 2011). Particularly, CRP was proposed to address the academic underachievement of underprivileged students and Students of Color such as African Americans, Latin*x*s, and Native Americans (Alismail, 2016; Bonner & Adams, 2012). Some studies, though few, show that CRP can successfully be implemented in mathematics classrooms (e.g., Aguirre, & del Rosario Zavala, 2013; Brown-Jeffy, 2009; Hernandez et al. 2013; Jackson, 2013; Leonard & Moore, 2014). Beyond implementation, there is evidence showing how the guidelines of CRP can promote academic engagement and achievement (e.g., Byrd, 2016; Christianakis, 2011; Dickson, Chun, & Fernandez, 2016; Rodriguez, Jones, Pang, & Park, 2004; Sleeter, 2012; Tate, 1995). Rubel and Chu (2011) demonstrated that their CureMap model provided students with broader and richer opportunities to learn mathematics. This was especially true with higher-level cognitive demand tasks, which facilitated deep engagement with mathematics and allowed students to detect patterns across mathematics representations.

Bonner and Adams' (2012) study reported that CRP inspires vibrant classroom discussions that uphold students' cultural integrity. The dynamic interactions they observed in their study contributed to students' mathematics success. Similar effects were seen in research by Jackson (2013) where healthy student-teacher relational interactions were key in mediating students' mathematics success. Jackson identified teachers' understanding of cultural competence, culturally relevant pedagogy, and critical consciousness as contributors to students' mathematics success. There are more studies that also confirm that CRP encourages a sense of critical consciousness (e.g., Epstein, Mayorga, & Nelson, 2011; Martell, 2013; Morrell & Duncan-Andrade, 2002; Stovall, 2006) among students.

Other benefits students often acquire from CRP exposure are positive racial/ethnic identity affirmation and positive attitudes towards others (e.g., Aldana, Rowley, Checkoway, & Richards-Schuster, 2012; Dessel, Rogge, & Garlington, 2006). This is also true in mathematics, where Waddell's (2014) CRP mathematics educators elaborated that CRP assisted students to preserve their cultural integrity as they aimed to attain academic excellence. When considering students' perspectives, Hubert (2014) found that students mostly had positive attitudes toward the use of CRP in mathematics. In fact, all of the students in the study preferred CRP over traditional methods of instruction. The students also indicated that CRP assisted to increase their interest in mathematics. Last, Byrd (2016) found that CRP is "an important method for promoting achievement and positive identities for students of all races" (p. 7). This is a significant result because of a common misconception that CRP only caters to one group and thus positive effects are unique to that group.

Why CRP is Not Implemented in Mathematics

There are several reasons why CRP is not generally implemented in mathematics courses. Among these reasons is the cultural incongruity between educators and students

(Ramsay-Jordan, 2017). When there is a misalignment between teachers' and students' culture, this often leads many teachers to rely on textbooks and preparation methods geared for standardized tests (Ramsay-Jordan, 2017). Irvine (2010) elaborates that lack of CRP knowledge causes many educators to avoid it and often resort to adopting slang speech, incorporating popular culture into the curriculum, or simply acknowledging ethnic holidays. Irvine continues that such practices are ineffective and may jeopardize the student-teacher relationships that are so important to successful implementation of CRP.

Wager (2012) states that educators' struggle to connect the mathematics students witness in school to the mathematics students practice out of school is another reason why they do not use CRP. Contextualizing mathematics to have real-world applications can be difficult, especially when the real-world applications are dependent on students' culture and interests. In fact, many educators believe that mathematics is culturally neutral. Leonard and Moore (2014) interviewed preservice teachers who showed reluctance to use CRP. The preservice teachers believed "math is math" (p. 82) and failed to understand "what culture had to do with mathematics" (p. 82). Similar sentiments appeared in Siwatu's (2011) study and he went further to identify teacher attitudes toward student diversity as another barrier to using CRP in mathematics. These attitudes can manifest with Students of Color being invisible to teachers, receiving low-expectations from teachers, and other deficit views (Ramirez, Gonzales-Galindo, & Roy, 2016).

Unlike teacher attitudes and racism, teachers can have biases that could constrain them from using CRP in mathematics. Biases refer to preferences and impartial judgement coming from prejudice (Jackson, Appelgate, Seiler, Sheth, & Nadolny, 2016). Specifically, many educators prefer to avoid controversial topics such as discussions based on race or ethnicity (Simic-Muller, Fernandes, & Felton-Koestler, 2015). These educators find such discussions to be uncomfortable and so they find refuge in a color-blind approach to teaching mathematics. Color-blindness equates to neutrality, and to wash one's hands in the struggle to include others' cultural references in education means to side with a "White curriculum." Such teachers are portraying personal biases, but there are also structural biases (Buchanan, 2016) that would limit implementation of CRP in mathematics classrooms. Structural biases can be university policies, culture, learning materials, and teacher practices. For example, textbooks are frequently culturally biased. That is, they do not show evidence of inclusion and equity (Bright, 2016; Oliver & Oliver, 2013). Instead, current mathematics curriculum, including textbooks, are deeply established in cultural experiences largely synonymous with America's White middle-class (Bright, 2016; Oliver & Oliver, 2013). Last, School Reform Models are also known to constrain educators from using CRP in mathematics classrooms. Reforms that support standardization and accountability often cause teachers to only satisfy the standards and prepare students for high-stakes tests (Ukpokodu, 2011). Infusion of cultural references in such instructional methods is rarely considered (Ukpokodu, 2011).

Conclusion on CRP

The reviewed literature showed a mixture of challenges and successes for educators who seek to implement CRP in mathematics. The consistently changing demographics and diverse settings on campuses indicate the growing need for educators to incorporate sociocultural factors and perceptions that positively affect interactions happening in classrooms (Wallace & Brand, 2012). However, the implementation of CRP in mathematics is limited and under studied (Bonner, 2014). Scholars state the implementation constraints are due to lack of CRP knowledge and models, cultural incongruity, perceptions of mathematics as culturally neutral, teacher attitudes towards students of color, personal and structural biases, and school reform models (Bonner, 2014; Gay, 2018; Ramsay-Jordan, 2017; Ukpokodu, 2011). The development of mathematics CRP models is highly encouraged (e.g., Brandt & Chernoff, 2014), especially in college undergraduate mathematics courses (e.g., Brown et al., 2019; Jett, 2013) where the researcher found no studies on the effectiveness of CRP.

Conceptual Framework

The conceptual framework is based on three main premises and the image presented in Figure 2 shows how these three premises interact. The first premise is that *Students of Color* (italicized are the main pieces of the conceptual framework) have been historical marginalized in education and their mathematics performance is, on average, significantly lower than White students. Students of Color are represented in the conceptual framework by the human figure. The dotted arrow labelled *math education* shows Students of Color's path to reach *mathematics success* (denoted as a graduation cap). The second premise is focused on the presence of *Whiteness and its resulting barriers for Students of Color in mathematics education*. As the literature review showed, Whiteness in mathematics education influences Students of Color's performance and learning experiences through deficit perspectives, a biased mathematics curriculum, and the under-preparation of teachers for culturally and linguistically different students. This premise is depicted as a barrier/wall that can block Students of Color's path to *mathematics success*.

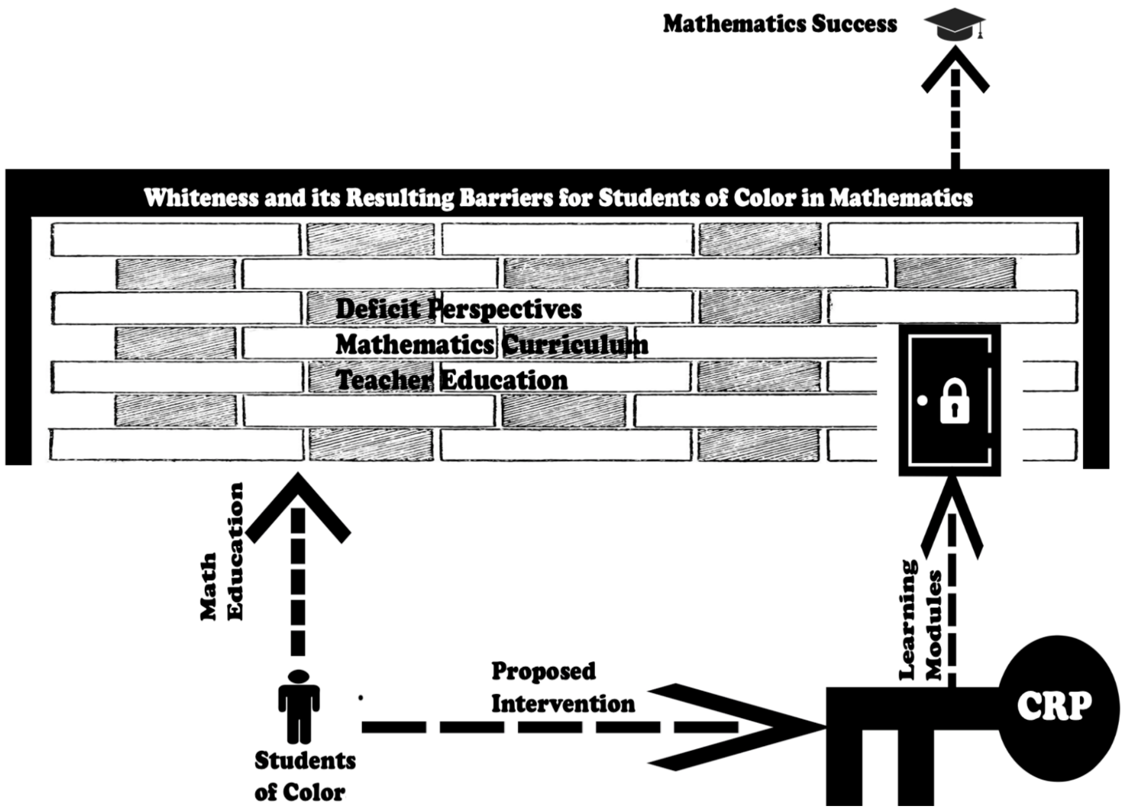

Figure 2. Conceptual framework.

The dotted arrow labeled *proposed intervention* points to CRP as a potential solution. CRP is the third premise and the review of the literature suggested how it has the potential to address some of the educational barriers in mathematics education. In the conceptual framework, CRP is symbolized as a key showing the potential for unlocking the door through the wall of barriers and toward mathematics success. Particularly, the key is designed with Hernandez et al.'s (2013) CRSMT model which has five principles:

content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development. The purpose of this study is to investigate the potential of Culturally Relevant Pedagogy (CRP) in an undergraduate mathematics course as a way to address disparities in mathematics learning. This is shown by a dotted arrow labelled *learning modules*, which also indicate a potential path to *mathematics success*.

Societal Ramifications of the Disparity in Achievement Levels

This dissertation study contributes to the literature by deepening understanding on how CRP Learning Modules were implemented in an undergraduate university mathematics course to support all students' learning. Information gathered from individual participants provided insights on how students perceived their learning experiences within the CRP modules. The dissertation review showed a dearth of research at this level. The need for CRP in higher education grows as institutions become more diverse. Approximately 40% of college and university students across the nation are identifying themselves as Asian, Black, Latin*x*, Native American, and mixed race (Primm, 2018). Lastly, the review of literature showed CRP to have potential in positively affecting students' learning. Byrd's (2016) study revealed that these positive effects can also be observed in White students as well. If disparities in achievement levels are not addressed, Students of Color will continue to demonstrate low graduation rates, high dropout rates, low college admissions and, eventually, limited economic opportunities. High rewarding jobs and upward mobility in society are often reliant on one’s level of post-secondary education. Mathematics should not be a filter or gatekeeper for students, mathematics should be a gateway to college and financial capital. Danziger and Haverman (2001) revealed that students’ access to these opportunities is a significant determinant of how they select political affiliations, a spouse, income potential, and employability. Nellis (2016) recognized education as among the factors that drives the disparity in incarceration rates. Rather than a school to prison pipeline, Students of Color must be guided to college and competency in mathematics as a crucial factor for success in life.

CHAPTER III

METHODS

This study was designed to explore the use of CRP embedded in Learning Modules in undergraduate mathematics courses as a way to address disparities in mathematics learning. The researcher designed three Learning Modules that leveraged the promising features of CRP. The Learning Modules were based on ACT mathematics topics because these topics are essential for student success in developmental and remedial undergraduate mathematics courses. This chapter presents the methods that were used to address the purpose and to answer the research questions.

Research Design

The research design used in this study was a sequential explanatory mixed-methods design (Creswell, 2003; Creswell & Plano Clark, 2011; Luck et al., 2006; Tashakkori & Teddlie 1998). This type of design starts with the collection of quantitative data, followed by the collection of qualitative data, in two consecutive phases to determine and explain the results. Particularly, the researcher analyzed quantitative data to determine if initial performance disparities between subgroups (Students of Color and White students) existed, how the CRP Learning Modules changed students' performance, and whether that change increased or decreased initial performance disparities. The quantitative phase informed the qualitative phase by exploring how the participants test scores were related to participants' perceptions of the CRP Learning Modules. Mixed methods designs can provide more confidence in the findings (McKim, 2017) and allow interpretation of different forms of data (Morse & Chung, 2003; Tashakkori & Teddlie, 2003). This design also maintains the strength of each methodology while reducing some weaknesses, bringing breadth, richness, and depth when compared with either qualitative or quantitative methods alone.

Piloting Activities

In preparation for designing and conducting this study, the researcher piloted one CRP Learning Module for the students in his course. The purpose of this piloting activity was to understand the logistics required to implement the Learning Modules during the dissertation study. The researcher identified some concerns during this process. A total of 35 students participated in the piloting activity, but this number proved to be a challenge for classroom management, especially during discussions. Due to this concern, the number of participants selected for this dissertation study was reduced to 20 participants. The last concern was that not all participants completed the pretest and posttest. This was often due to participants arriving late or leaving early during the class sessions. To address this, the researcher only provided incentives to participants if they completed the whole study.

Development and Implementation of the Learning Modules

Each Learning Module covered one intermediate algebra topic and was referred to as Learning Module 1, 2, or 3. Learning Module 1 covered linear inequalities, Learning Module 2 covered systems of equations, and Learning Module 3 covered absolute value equations. Understanding of these three Learning Modules is highly dependent on participants having the fundamental knowledge of how to solve linear equations. Due to the Covid-19 Pandemic, that was ongoing at the time of data collection, participants in the study completed the CRP Learning Modules online (live stream).

The modules included five main parts: a Pre-module Discussion, Peer Introductions, Topic Introduction, Practice Problems, and a Case Study. The sections to follow will discuss how these components fit with Hernandez et al.'s (2013) Culturally Responsive Science and Mathematics Teaching (CRSMT) model (Appendix I). The model has five main principles: content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development.

Pre-module discussion. During the pre-module discussion, participants watched a short film on the use of Navajo language and culture in mathematics curriculum. The purpose of the film was to show the participants that mathematics and mathematical knowledge are found in a particular race's sociocultural frame (Hernandez et al., 2013). It was anticipated that the film would also encourage participants to think about how the mathematics they have witnessed relates or does not relate to their culture. Discussions on the film were carried out online via Microsoft (MS) Teams. By hosting discussions online, it was expected that participants would begin to be comfortable to discuss issues on race, culture, and mathematics before they entered the Learning Modules. The instructor also participated in the discussion. He did not censor free speech, and he offered positive responses to all participants to promote participation and independent thought.

The CRSMT model details that encouraging independent thought is one way of facilitating knowledge construction. Furthermore, the model details that creating a safe learning space for students to participate is part of building positive student-teacher relationships and a critical part of content integration. The discussions also occurred between participants. If these interactions were positive then it could aid in prejudice reduction (Hernandez et al., 2013). The researcher/instructor closed the discussion by expressing his beliefs that all participants are capable of learning and doing rigorous and high-level mathematics. High expectations of the participants were maintained throughout the Learning Modules because this is among the most defining aspects of CRP and content integration (Hernandez et al., 2013). The discussion marked the beginning of talks about race, culture, and mathematics that were to follow in the Learning Modules.

Peer-introductions. In continuation of promoting positive teacher-student and student-student relationships, the instructor hosted icebreakers for the first 10 minutes of each Learning Module. This was an attempt to make participants comfortable to interact with each other and with the instructor. The instructor participated in these activities with the participants. The icebreakers were games based on race and culture so that participants were comfortable to discuss such issues. The activities were retrieved from Clark (2004) and Appendix L illustrates some of those activities. According to the CRSMT model (Appendix I), building towards positive teacher-student and student-student interactions, by creating safe learning environments, is an important part of content integration and prejudice reduction.

Topic introduction. During the Topic Introduction, the instructor spent 30 minutes to introduce the new mathematics topics and concepts in each module. The instructor explained the concepts by using real world examples which students frequently encounter. For example, in Learning Module 1, the instructor explained how some budget restrictions can be modelled by using Linear Inequalities. Furthermore, the instructor always began from what participants already knew. For example, the instructor built on Linear Equations content knowledge when introducing Linear Inequalities. Apart from prior academic knowledge, the instructor also leveraged participants' cultural knowledge by connecting the mathematics they learned to their culture. In Learning Module 1, the instructor used Linear Inequalities to compare the number of interracial marriages at different time points. The instructor then prompted the participants to think why interracial marriages have been increasing with time and how their own culture has changed through time to allow or disallow interracial marriages.

During this period, the instructor played the role of a facilitator and employed techniques that allowed participants to discover algorithmic processes that were otherwise assumed to be standard. In the case of solving linear inequalities, the instructor gave participants a worksheet of problems to attempt until they discovered patterns that could be standardized. Specifically, the pattern they discovered is that dividing or multiplying both sides of an inequality by a negative number causes the direction of the inequality sign to change. Such methods were applied in all of the Learning Modules, however, there were instances where the instructor gave information. For example, mathematical notations, such as representing a $\leq$ or $\geq$, were given to the participants, rather than them discovering or inventing new notations. Throughout the Learning

Modules, the instructor allowed and encouraged participants' to express different viewpoints on issues and solution methods. This aligned with the facilitating knowledge construction piece of the CRSMT model (Appendix I).

Practice problems. During the Practice Problems portion of the modules, the goal was to provide fluency and reinforce conceptual understanding on topics covered in the Learning Modules. In Learning Module 1, participants were given situations (contextualized problems) where they had to write the appropriate linear inequality, solve it, and then graph it. For example:

> *A bunch of HipHop artists such as Drake and J. Cole dropped new albums over the weekend. You want to use the $50 iTunes gift card you received from Aunt May to buy some of the albums. If iTunes has a one-time subscription fee of $5 and an album costs $10. How many albums can you afford before over spending the amount on the gift card?*

The consumption of Hip-hop music, even though rooted in Black culture, and the use of iTunes are common activities across cultures. The researcher designed such practice problems that connected to participants' daily lives and, according to the CRSMT model, achieved content integration.

Participants worked individually first, and then they gathered in groups to discuss their solutions. They worked in groups of four with heterogenous grouping configurations based on race as recommended for CRP by Ukpokodu (2011). Rosser (1998) explains that four members per group is ideal, given the task has multiple parts. She continues that some researchers have reported poor participation if the number of group members exceeds four. The instructor moved across groups and aided participants if they had questions. However, the instructor only assisted by providing hints and not full solutions.

The goal was to allow collaborative learning and maintain high expectations through productive struggle and scaffolding for the participants. These notions are key to facilitating CRP and can be seen under content integration and academic development in the CRSMT model (Ukpokodu, 2011).

Case study. The Case Study portion of the Learning Modules used a real-world case that affected multiple racial demographics. Participants collaborated for 30 minutes to grapple with a series of questions, which allowed each group member's input (this time the participants worked in different groups, but the group size was still four and the configurations were still based on race). In Learning Module 1, for example, the case study focused on gentrification and how it affects local communities and their cultures (see Appendix M). The instructor shared a short video to demonstrate gentrification and its impact in a San Francisco neighborhood and gave participants a Linear Inequality model created from real data on gentrification. The participants gathered in groups and worked on the case study. The groups graphed, solved, and interpreted the model. They argued the benefits and drawbacks of gentrification in their local communities and culture. This was the structure of all case studies in the modules. Learning Module 2's case study was on mental health (see appendix N) and Learning Module 3's case study addressed medical marijuana and marijuana arrests based on race (see Appendix O).

The instructor also acted as an agent of change by informing participants how to stop/encourage gentrification through their city councils. The use of videos, group collaborations, real-world cases, and mathematical models are all learning opportunities that align with the CRSMT model in providing academic development. In addition, these case studies promoted social justice by providing methods to question and challenge gentrification as it occurs in their communities. Ladson-Billings (1992) explained that part of CRP is to develop critical consciousness by judging social, political, inequity, and economic issues. The Learning Modules aimed to instill democratic values, rules, behaviors, and participation roles especially while doing group work in mathematics (Ukpokodu, 2011).

Participants

A total of 20 university undergraduate student participants, who were fluent English speakers, were recruited for the study. However, only 19 participants completed the study. The participant that dropped out was a male Student of Color. Among the participants, 9 were Students of Color and 10 were White. In the case of gender, 9 participants were male and 10 were female. Within the nine Students of Color, seven identified as Latin*x* and two identified as Black. Fourteen of the participants were freshmen, two were sophomores, another two were juniors, and one was a senior. For household income, 14 participants selected a household income of less than $30,000 and the remaining 5 participants fell between $40,000 and $60,000. The average age of the participants was 22.

Data Sources/Instruments

The study began with an initial linear equations screening test to identify participants, and then used three data sources: pretests/posttests, participant questionnaires, and individual interviews (Creswell, 2017). The following sections include information on each of these instruments.

Linear Equations Screening Test

The Linear Equations Screening Test (see appendix A) included 20 questions on how to solve linear equations. The screening test was given as a chapter test in all of the beginning algebra sections at the researcher's university before recruitment began. The questions covered key concepts that addressed: using properties of equality, combining like terms, clearing out fractions or decimals, slope intercept forms, graphing, recognizing identities, and recognizing equations with no solutions. The purpose of the Linear Equations Screening Test was to select and recruit participants that had the prerequisite knowledge (i.e., solving linear equations) to complete the three CRP Learning Modules designed for the study.

Pretest and Posttest

The first source of data was one pretest and one posttest with a total of 21 questions on each test that covered the three selected topics. The test included seven questions focused on the topic of each Learning Module. Learning Module 1 questions assessed absolute value equations. Learning Module 2 questions asked participants to solve and graph systems of equations. Learning Module 3 questions asked participants to solve and graph linear inequalities. The selected number of questions was sufficient to cover the critical concepts in each topic. The questions on the pretest and posttest were selected from previous ACT exams and practice exams from the past four years. The two tests contained different questions, but the questions were similar in nature, they covered the same topics, and were of the same rigor. The researcher, together with two experts on the content (absolute value equations, systems of equations, and linear inequalities) and the ACT, ensured that the questions were directly related to the ACT and the three topics. The questions used a multiple-choice format, as they would appear on the ACT. The pretest (see Appendix B) served as a benchmark measure to assess participants' mathematical knowledge of the topics prior to completing the Learning Modules. The posttest (see Appendix C) documented any changes in participants' mathematical knowledge of the topics after completing the Learning Modules.

Participant Questionnaire

The second data source was a participant questionnaire (see Appendix D). The purpose of the questionnaire was to collect information on participants' experience, especially what they found effective or ineffective, while engaging with the Learning Modules. The questionnaire included 13 open-ended questions that addressed: what participants found different about the modules compared to their traditional classes, why participants may or may not choose to learn mathematics with these modules, what aspects of the modules participants identified as effective or ineffective, and how the combination of mathematics and culture influenced their learning.

Individual Interviews

The third source of data was individual interviews with all of the participants. Merriam (2009) suggests interviews as among the main sources for collecting qualitative data. The purpose of the interviews was to provide an in depth look at how CRP elements of the Learning Modules influenced participants' learning processes. The researcher used a researcher-developed interview protocol (see Appendix E) to conduct the 20- to 30-minute semi-structured interviews (Cohen & Crabtree, 2006). The researcher used Castillo-Montoya's (2016) interview protocol refinement (IPR) framework to develop the interview tool. The framework's four-phase process includes: creating an inquiry-based conversation, ensuring interview questions align with research question, receiving feedback, and piloting the interview protocol. Interviews shed light on which specific parts of the design of the Learning Modules the participants found to be most (in)effective. The use of the IPR framework improves the reliability of the interview protocol (Castillo-Montoya, 2016). It is also important to note that, after the interviews, and having time to reflect, some participants wished to add more about their experience with the CRP modules. This resulted in unsolicited emails which were included as part of the participants' data.

Procedures

The procedures included seven major steps: Linear Equations Screening Test, Pretest, Learning Modules, Posttest, Participant Questionnaire, and Individual Interviews. The sections below explain each of these steps.

Sampling Design: Linear Equations Screening Test

All undergraduate students enrolled in beginning algebra at the researcher's university learned about linear equations during the first two months of the semester. After completing those topics, potential participants completed the screening test as a chapter exam, which was part of their course program. Participants that scored 70% or above were invited to participate in the study. The score 70%, which is a C- grade as designated by the university, is consistent with the university's recommendations for the required level of content knowledge to progress to a subsequent mathematics course.

Sampling Design: Learning Modules

From the volunteers that passed the Linear Equations Screening Test, the researcher randomly selected 20 participants (10 Students of color and 10 White participants) with scores of 70% and above to participate in the study. Due to the exploratory nature of the study, 20 participants were adequate to achieve the basic descriptive statistics (rather than inferential statistics) and qualitative data analysis for evaluating the influence of the Learning Modules.

Pretest

First, the 20 participants electronically signed the consent form via Qualtrics. Then participants completed the pretest online via Qualtrics during Week 2 of the study (see Table 2). The test was open the whole day to increase availability of the pretest for participants. Participants were allowed to use a basic calculator during the pretest. After completing the pretest, participants responded to several questions reporting their demographic information (also via Qualtrics).

Table 2

Schedule of the Data Collection Activities

Week	Day	Time	Activity
1	Tuesday	In class	Linear Equations Screening Test
1	Wednesday - Friday	Online	Consent, Pretest, and then acquiring demographic information
2	Monday to Thursday	Online	Discuss video on MS Teams
2	Friday	5:00pm – 6:20pm	Module 1
2	Saturday	5:00pm – 6:20pm	Module 2
3	Monday	6:00pm – 7:40pm	Module 3
3	Tuesday – Wednesday	Online	Posttest, Questionnaire
3	Friday – Saturday	All day	Individual Interviews

Completing the Modules

During Week 2 of the study, participants watched and discussed a short film on Navajo language and culture in mathematics curriculum. Questions for the discussion were posted on MS Teams. During Week 2 and 3 of the study, the participants completed the three Learning Modules online (live stream) via MS Teams. The researcher served as the instructor and conducted peer-introductions (icebreakers), topic introduction, practice problems, and a case study during the implementation of the modules. (See detailed information on this implementation process in the previous section titled: Development and Implementation of the Learning Modules.)

Posttest

In Week 3, after the participants completed the Learning Modules, they completed the posttest. Similar to the pretest, participants completed the posttest online using Qualtrics. The test was open the whole day to promote participants' availability to complete it. Basic calculators were allowed on the posttest.

Questionnaire

Also in Week 3, immediately after the posttest, participants completed a questionnaire online via Qualtrics. The questionnaire took approximately 20-30 minutes to complete.

Individual Interviews

After completing the questionnaire, the researcher conducted individual interviews with all 19 participants. The interviews were conducted online via Microsoft Teams. The researcher followed the interview protocol (see Appendix E) while voice recording the conversations. The participants provided their responses to the researcher during the interviews and also after the interviews were over. For example, as an extension of the interviews, some participants spontaneously emailed the instructor to provide more feedback on the modules based on the questions from the interview. These emails were unsolicited but did provide valuable data as an extension of the interview process.

Validity

This study used both quantitative and qualitative methods to understand how the CRP Learning Modules influenced student learning experiences and achievement levels. The use of two methods in data collection helped to improve the validity of the study by answering the research questions from multiple perspectives. For the quantitative portion, the researcher selected questions based on the three identified topics from recent ACT exams which have high content validity (ACT, 2018). Two independent experts cross-checked that the questions on the pretest and posttest were directly related to the intended topics in the Learning Modules (Creswell, 2014). This ensured that the pretest and posttest measured the concepts of absolute value equations, systems of equations, and linear inequalities.

Data Analysis

This section presents details about the analysis of each data source to answer the three research questions. Table 3 shows how the data for each research question is matched with the methods for analyzing the data.

Table 3

Research Questions and their Data Analysis Methods

Research questions	Data sources	Data analysis method
1. How do participants' mathematics performance scores change after using CRP mathematics Learning Modules and how does that change appear among subgroups (Students of Color and White)?	Prescores and postscores	Descriptive statistics Paired samples t test Independent samples t test
2. How do participants evaluate the general aspects of the Learning Modules in terms of the quality of the modules for mathematics learning? Are there evaluation patterns based on the two subgroups of participants (Students of Color and White)?	Questionnaire	Attribute and structural coding
3. How do the participants perceive that the elements within each Learning Module directly supported or hindered their individual learning? Are there perceived patterns based on the two subgroups of participants (Students of Color and White)?	Individual interviews	Attribute and structural coding

Analysis of the Quantitative Data:
Pre- and Post-scores

The analysis for RQ #1 focused on how participants' mathematics performance scores changed after participation in the CRP Learning Modules. The analysis began by computing descriptive statistics and developing boxplots for the prescores, postscores, and change in scores. The boxplots assisted in showing variation within scores (Moore & McCabe, 2002). The researcher also used histograms to present each participants' prescore and postscore. Next, the researcher conducted a paired samples *t* test to determine changes in all scores and changes in scores by subgroups (Students of Color and White). The *t* tests were appropriate because the sample was randomly selected from a pool of volunteers. The Students of Color sample and the White sample was representative of the university's Students of Color and White students based on distributions of the following demographics: race, gender, socioeconomic status, and age. In addition, the screening test also assured that there were no significant performance gaps between the Students of Color and White participants from the beginning.

Analysis of the Qualitative Data:
Questionnaires and Interviews

The analysis for RQ #2 focused on what aspects of the Learning Modules the participants found effective or ineffective for their learning. This question used the questionnaire responses for all participants by separating them into subgroups. The researcher downloaded the responses from Qualtrics as an excel file for analysis. Next, the responses were uploaded to Nvivo, a qualitative data analysis program. The data were analyzed from a deductive coding perspective. Specifically, the researcher began with a coding frame developed from the literature that aligned with culturally relevant pedagogy (Appendices F, G, and H). The first phase of the deductive coding was attribute coding, where the researcher identified attributes such as ethnicity, and pre-and post-test scores. Next the researcher used the coding frame in a process of structural coding based on the CRSMT model (Appendix H). Saldaña (2016) explains that this deductive approach (attribute and structural coding) is aimed at testing theory. This method of coding highlighted themes in all participants' responses on what they found effective or ineffective in the Learning Modules.

The analysis for RQ #3 focused on an in depth understanding of participants' perceptions about the elements within each Learning Module that directly supported or hindered their individual learning. The researcher transcribed audio data from the individual interviews and used Nvivo to analyze the interview transcripts and the unsolicited emails. The researcher used a deductive coding perspective and began with a coding frame based on the literature. An expert in qualitative data analysis substantiated that the developed codes were appropriate before data analysis. By coding in this manner, themes that elaborated the supporting or hindering elements of the CRP Learning Modules were developed from participants' responses.

Convergent Mixed Methods Analysis

After completing the two separate analyses (QUANT and QUAL), the results were merged to answer the overarching research question: How does the use of CRP in undergraduate mathematics Learning Modules support students' mathematics learning? This was achieved by using a convergent mixed methods design (Creswell & Plano

Clark, 2011). The two independent analyses offered "an understanding of the phenomenon under investigation" and were merged into "meta-inferences" (Teddlie & Tashakkori, 2009, p. 266). A meta-inference is defined as "an overall conclusion, explanation, or understanding developed through an integration of the inferences obtained from the qualitative and quantitative strands of mixed methods study" (Tashakkori & Teddlie, 2010, p. 101). This is in accordance with Creswell and Plano Clark's (2011) suggestion that researchers should "analyze quantitatively and…qualitatively and then merge the two sets of results" (p. 71). In this study, quantitative data analysis offered inferences on how participants' mathematics scores changed after exposure to CRP mathematics Learning Modules and how that change appeared in subgroups (Students of Color and White). Qualitative data analysis offered inferences on:

1. Participants' overall evaluations of the Modules and whether those evaluations were also based on subgroups (Students of Color and White).
2. Participants' perceptions of how specific elements within each Module directly supported or hindered their individual learning.

Thus, the researcher was able to answer the overarching research question by merging the quantitative and qualitative analyses.

Limitations

In this study, there are four limitations to be considered. First, the researcher served as the only coder of the data due to limited resources and time. This may have influenced the qualitative analysis and the interpretations. Second, the participants who volunteered for the study may have had a better perspective on mathematics or culture than the general population of mathematics students. That is, participants' performance could have been inflated, relative to students from the general population, due to their interest in the study. Third, the instruments (pretest, posttest, modules, and screening tests) were researcher developed, and so, these instruments were limited to the researcher's expertise. To address this limitation, the researcher asked colleagues (with a strong background in mathematics) to evaluate the instruments and Learning Modules to gauge if they were appropriate for the covered mathematics topics and aligned to the CRSMT model. Lastly, due to a small sample size, it is probable that type II errors were inflated in the hypothesis tests conducted in this study. Granted, this implies that the tests were "underpowered," but it does not mean that the tests were moot. This is true because statistical power is both a function of sample size and effect size. The researcher also considered effect size in these tests.

CHAPTER IV

RESULTS

The purpose of this study was to explore the use of CRP in an undergraduate mathematics course as a method to address disparities in mathematics learning. The researcher developed three Learning Modules based on the CRP principles. The researcher gathered pretest and posttest scores from 19 participants before and after they experienced the CRP mathematics Learning Modules. Participants' evaluations of the modules were also conducted using a questionnaire and individual interviews.

In the sections below, participants' performance scores are presented first, followed by participants' general evaluations of the Learning Modules and what supported or hindered their learning. The chapter closes with the mixed methods results. In this chapter, all participants are given a pseudonym that uniquely identifies them. The pseudonym begins with the subgroup (SC-Student of Color or W-White) followed by their gender (M or F) and then a two-digit number. For example, WF02 would be a White female who was assigned the number 02, and SCM01 would be a Student of Color that is male and is assigned the number 01.

Change in Participants' Scores after Using Culturally Relevant Pedagogy Mathematics Learning Modules

The first research question focused on changes in participants' mathematics performance scores after using the CRP mathematics Learning Modules. The results below present these changes for the participants overall ($N = 19$) and within the two subgroups (Students of Color and White). It is important to recall that 20 participants were recruited, however, only 19 of them completed the study. The participant (SCM10 - Latin*x*) that dropped out scored 47% on the pretest, but this score is not included in the results below.

Overall Change in Scores

The first result focuses on overall changes in participants' mathematics performance scores after using the CRP mathematics Learning Modules. The researcher computed descriptive statistics for participants' prescores, postscores, and change in scores. Table 4 shows the descriptive statistics for all participants' scores and also disaggregates the scores based on subgroups (Students of Color and White).

Table 4

Descriptive Statistics for Prescores, Postscores, and Change Scores

	All (*N* = 19)			Students of color (*n* = 9)			White (*n* = 10)		
Variable	*M*	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range
Prescores	45	20	10-76	45	24	10-76	46	16	14-71
Postscores	59	18	28-86	66	16	43-86	52	17	29-81
Change scores	14	17	-19 – 38	22	13	-5 – 38	6	19	-19 – 29

Note. All numbers in the table are presented in percentages.

In Table 4, it is important to note that the overall score means for all participants (*N* = 19) on the 21-question pretest and posttest improved from 45% to 59%, a change of 14%. In addition, the mean scores for both Students of Color and White participants improved from 45% to 66% and 46% to 52%, respectively. Of the two subgroups in the table (Students of Color and White), the Students of Color had the largest change in scores (22%) while White participants had a 6% change in scores. The key takeaway from Table 4 is that the Learning Modules increased participants' scores, both as a group and individually.

Figure 3 is a boxplot that displays participants' overall prescores and postscores. This figure visualizes the descriptive statistics and also presents how the mean and range, from prescores to postscores, improved. The boxplot in Figure 3 shows that the overall group scores increased from the pretest to the posttest. This indicates that the CRP modules had a positive impact on participants' performance.

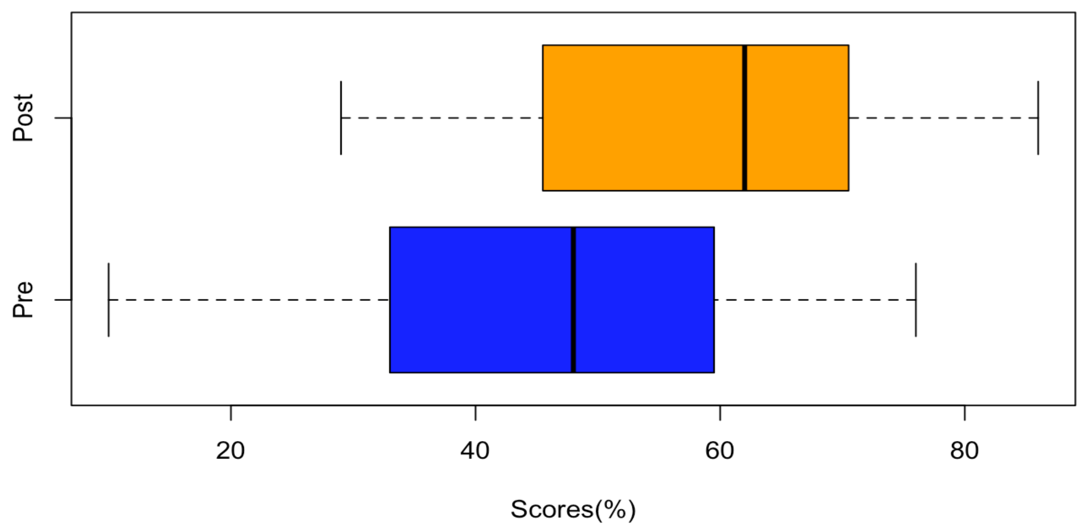

Figure 3. Boxplots comparing prescores (Pre) and postscores (Post) for all participants.

Next, the researcher used a paired samples *t* test (two-tailed) to assess significance in the improvement of scores between the pretest and posttest for all participants. For the purposes of conducting the t-test, the assumptions for *t*-tests were first assessed. Based on the design of this study, each participants' scores were independent from other participants' scores. For the normality assumption, the difference in prescores and postscores were found to have a skew = - 0.754 and kurtosis = - 0.300, which meant the scores were sufficiently normal (i.e., skew < |2.0| and kurtosis < |9.0|; Schmider, Ziegler, Danay, Beyer, & Buhner, 2010). Homogeneity of variance was also satisfied with a Pitman-Morgan test, $t(17) = 0.519$; Gardner, 2001). Thus, even with a small sample size, the paired samples *t* test was associated with a statistically significant effect, $t(18) = -3.412$, $p = 0.00295$. Cohen's *d* was also approximated at 0.8, implying that there was a large effect according to Cohen's (1992) benchmarks.

Change in Scores by Subgroups

The next result for RQ #1 focused on changes between the prescores and postscores for participants within the two subgroups (Students of Color and White). Figure 4 shows the prescores and postscores for each participant. This figure is arranged in four parts to show White participants whose performance increased and decreased, and Students of Color whose performance increased and decreased, with participants who increased on the left, and those who decreased on the right.

Figure 4 indicates that none of the scores stayed the same for any of the participants, and only four participants' scores (WM06 - White, WM02 - White, WF03 - White, and SCF04 - Black) decreased. This result shows that the CRP modules had a positive impact on the majority of the participants' performance and that more White participants (3) decreased in performance compared to Students of Color (1).

Figure 5 shows boxplots for prescores and postscores for Students of Color and White participants.

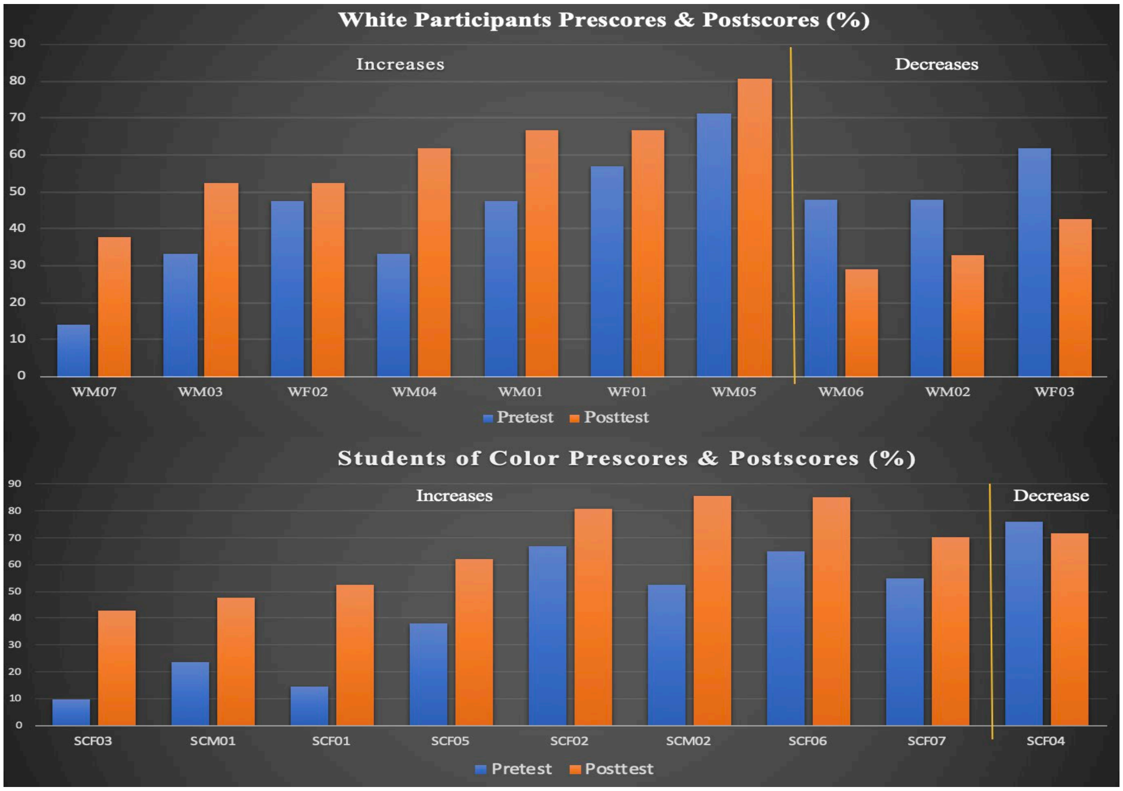

Figure 4. Participants' prescores and postscores.

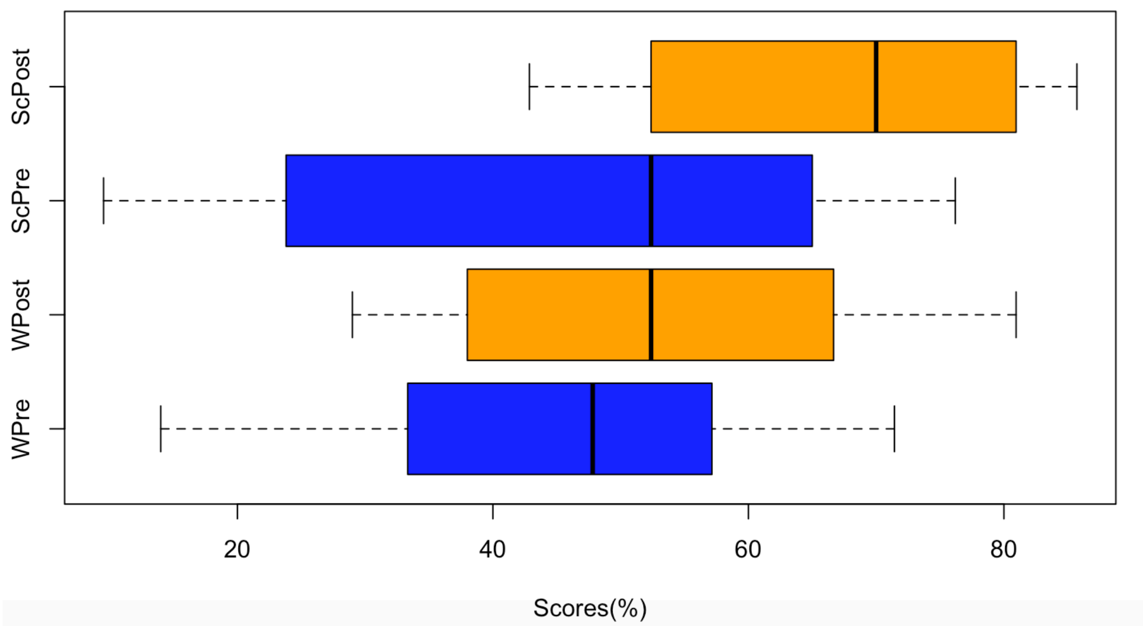

Figure 5. Pretest and posttest performance by subgroup (Students of Color pre/postscores – ScPre/ScPost and White pre/postscores - WPre/Wpost).

Figure 5 emphasizes, that the gain between prescores and postscores was greater for Students of Color than for their White peers. The scores between subgroups suggests that Students of Color may have gained more from the CRP modules than their White peers. The researcher conducted an independent samples *t* test to check whether one group improved more than the other and whether that improvement was statistically significant. Two assumptions, normality and homogeneity of variance, were verified before running the *t* test. For normality, the gains for Students of Color had skew = -0.913 (standard error = 0.717) and kurtosis = 1.188 (standard error = 1.400) and the gains for White participants had skew = -0.398 (standard error = 0.717) and kurtosis = -1.690 (standard error = 1.400), thus sufficiently normal according to Schmider et al. (2010). Homogeneity of variance was also satisfied with Levene's *F* test (Null: variances of the two subgroups' gains are approximately equal), $F(17) = 1.5$, $p = 0.237$. That is, with $p = 0.237$ being higher than $\alpha = 0.05$, the null hypothesis (equal variance) was accepted. The independent samples *t*-test showed a statistically significant effect, $t(17) = 2.172$, $p = 0.044$. Thus, the improvement for Students of Color was significantly higher than for the White participants.

General Evaluation of the Learning Modules

This section discusses participants' general evaluation of the Learning Modules, what supported or hindered their individual learning, and presents participants' evaluations based on subgroups (Students of Color and White). The following subsections provide more details.

Participants' General Evaluation of the Learning Modules and What Supported or Hindered their Individual Learning

The qualitative results in this section are presented by combining the results for research questions 2 and 3 to synthesize participants' general evaluations of the Learning Modules (RQ 2) and what supported or hindered their learning (RQ 3). Research question 2 used a questionnaire with nine open-ended questions and four Likert-scale questions, while research question 3 used individual interviews together with unsolicited emails. Table 5 shows the open-ended questions that were asked on the questionnaire and during the individual interviews.

Participants' responses were organized in themes based on Hernandez et al.'s (2013) CRSMT model. The main themes that appeared in participants' responses were content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development. Table 6 shows these themes and how they are defined by Hernandez et al.'s (2013).

General evaluation of content integration. Out of 19 participants, 16 identified the presence of culture, a component of content integration, as an effective aspect of the Learning Modules. In addition, 17 participants stated that they found their culture and interests represented in the modules. These participants detailed that the presence of culture made their experience richer and made them care and recall the mathematics being taught. WM03 (White) described his experience by stating: *"We really focused on being individuals and speaking to our cultures, as well as applying the math we learned to things that really matter to us."* SCM02 (Latin*x*) explained that the modules had "*...a*

Table 5

Questionnaire and Individual Interview Questions

Questionnaire questions	Interview questions
What did you find different about the Learning Modules compared to prior mathematics classes you have taken?	Did the Learning Modules help you learn? a. If yes, what aspects of the Learning Modules helped you learn? b. If no, what aspects of the Learning Modules did not help you learn?
What aspects of the mathematics Learning Modules did you find most effective in your learning process?	How did your unique background/identity/culture contribute to your learning process and the learning process of others?
What aspects of the mathematics Learning Modules did you find least effective in your learning process?	What was different about learning using the modules compared to prior mathematics classes you have taken?
How does the combination of mathematics and culture influence your ability to learn?	Describe the learning environment? a. Describe the interactions/relationship you had with the instructor as you experienced the Learning Modules? b. Describe the interactions/relationship you had with classmates as you experienced the Learning Modules? c. How did these interactions/relationships help and/or hinder your ability to learn?
How does the availability of free learning tools, such as MS Teams, affect your ability to learn mathematics?	Did you find the mathematics you learned in the modules to be meaningful? If so, how?
Describe the rigor of the Learning Modules and how this affected your learning?	Has your attitude towards mathematics change during the Learning Modules? If so, how?
Explain how the interactions you had with your peers affected your learning process?	Describe your level of engagement during the Learning Modules. What aspect of the Learning Modules can you attribute to your level of engagement?
Explain how the interactions you had with your instructor affected your learning process?	Was the time allocated to complete the Learning Modules enough?
Why might you choose or not choose to use these modules when learning mathematics?	Did you find your background/interests/culture represented in the Learning Modules? If yes, how was it represented and did it help you learn?
	How did the use of Microsoft Teams compare to your previous experiences learning mathematics?
	How useful did you find the learning aids (e.g., videos and example problems)?
	Are there any more comments you would like to add about the Learning Modules?
	Was there anything missing in the Learning Modules that you wish you had? And why?

Table 6

Culturally Responsive Science and Mathematics Teaching Model

Content Integration		
The inclusion of content from other cultures	**The fostering of positive teacher-student relationships**	**Holding high expectations**
• Incorporating information and/ or examples from different cultures. • Making connections to students' everyday lives. • Relating teacher background to their CLD students through language and similarities in home culture.	• Building of positive student-teacher relationships • Building of a safe learning environment to participate in classroom discussions without fear of reprisals or negative comments from the teacher.	• Holding high expectations for all students in the science and math classroom. • Identifying the importance of high expectations in helping the students to achieve academically as well as socially.
Facilitating Knowledge Construction		
Build on what the students know	**"Real world" examples**	**Assist students in learning to be critical, independent thinkers who are open to other ways of knowing**
• Demonstrating the ability to build on students' background/ prior knowledge as a means to making science and math concepts accessible.	• Using 'real world' examples during science and math lessons, especially when introducing new concepts.	• Assisting students in effective communication. • Motivating students to desire to learn and think independently.
Prejudice Reduction		
The use of native language support	**Positive student-student interactions**	**Safe learning environment**
• Using native language support for ELL students. • Communicating with parents in the native language.	• Fostering positive student-student interactions.	• Creating a safe environment.

Social Justice	
The teacher's willingness to act as agents of change	**Encouraging their students to question and/or challenge the status quo in order to aid them in the development of sociopolitical or critical consciousness accomplished through modeling**
• Advocating for students; act as agents of change.	• Encouraging students to question and/or challenge the status quo. • Assisting students in becoming good citizens.
Academic Development	
The teacher's ability to create opportunities in the classroom that aid all students in developing as learners to achieve academic success	**The use of research-based instructional strategies that reflect the needs of a diversity of backgrounds and learning styles**
• Using a variety of methods to create learning opportunities. • Using visuals, grouping, and hands-on or manipulatives during instruction in order to assist their students in meeting the objectives of the science and math lessons. • Using modeling to illustrate difficult science and math concepts.	• Using the sheltered instruction model as well as the SIOP model. • Using real world models such as rocks, plants, clocks, etc. when introducing new or difficult • concepts in science and math lessons. • Using whole and small group collaborations.

Note. CRSMT model from Hernandez et al.'s (2013).

really great method for me to pay attention and be involved in the class, including the cultural parts of the classes…So it was really inspiring." WM03 (White) stated that the presence of culture *"…makes you understand it [mathematics] and want to think of it more. It just makes it more human…like it makes it something more than just like numbers on a paper."* SCF02 (Latin*x*) referred to a particular discussion she had in class and detailed; "*People listen to numbers. If I state that police are killing more People of Color than White people, people cannot see how much more. So knowing how to show that is important to get my point across as to why it is such a big issue."* SCM02 (Latin*x*) summarized the experience of others by stating, "*I felt as if I learned much more than just maths."*

The participants who appreciated the presence of culture were also specific in recalling the interests/cultural aspects that resonated with them. For example, SCF04 (Black) recalled the computations and discussions around mental health and expounded how, in her Black family, it is hard to discuss mental health issues and was certain that her family would advise her to "pray it away." Another example was reported when linear inequalities and gentrification were combined, and SCF02 (Latin*x*) argued, "*They pretty much kick us out. This is what happened in my old neighborhood…it feels like I don't belong anywhere."* SCM02 (Latin*x*) explained that the presence of sociocultural issues felt like the modules were "… *telling me, hey, I see you, you're there. I know where you come from… It [presence of culture] helped me, like, be involved, like saying, hey, this actually speaks of me, I should care about it, too."* Furthermore, SCF03 (Black) described the presence of culture "… *did make me feel included.*" That said, not all participants appreciated the presence of culture in the modules. WM05 (White) and WM02 (White) were two participants who reported that they could not relate to the modules. Specifically, WM05 (White) said he felt the modules were more tailored to the African American culture and WM02 (White) asserted that the presence of culture in modules did not affect his learning at all.

The student-teacher relationship, reported by 17 out of 19 participants, was another piece of content integration that was attributed to the effectiveness of the Learning Modules. Participants' comments attested that the instructor did participate in the discussions, but more importantly, that he was willing to be vulnerable by sharing his own perspectives. SCM01 (Latin*x*) spoke to this by explaining, "*It was really great to have a teacher that actually cared for what was being discussed. I felt listened and encouraged to participate, and I don't do that often.*" WMO3 (White) stated, "*My instructor was very open and honest about his opinions and personal history, which allowed for us to become invested in what he was saying as well.*" Words like "*woke*," "*chill*," "*understanding*," and "*nonjudgmental*" were often used to describe the instructor. Two of the 17 participants explained that the instructor was professional and non-hostile when difficult topics were discussed. Six of the 17 participants observed that the instructor was unwilling to leave a student behind if she or he did not understand something.

Level of expectation, an element of content integration, was discussed by 4 of the 19 participants. For example, SCM01 (Latin*x*) identified that the learning environment, together with the high levels of expectation, aided him to understand the material.

SCM01 (Latin*x*) went further and explained that there were times when the instructor expected us to solve the "…*equations on our own. I learn better by doing, so it worked out great. In the past my math teachers always solved the question for us*." Three other participants described the modules as a productive challenge.

General evaluation of facilitating knowledge construction. Real-world examples are a facet of facilitating knowledge construction. All participants, except WM01 (White), found the use of culturally relevant, real-world examples to be an effective part of the Learning Modules. Most participants valued how mathematics could be applied to real life, but they valued it even more when the real-world examples were built on issues they cared about. WM03 (White) described the real-world problems as "…*not very difficult and not very straightforward. I don't appreciate it when teachers give hard questions for no reason. The hard questions in the Learning Modules all had good reasons to be difficult - they were real*."

Participants explained the complexity of the real-world examples, such as discussions on medicinal marijuana, mental health, or gentrification, because they did not have a "right" answer. But it was this complexity that made the examples more intriguing. Rather than just culturally relevant real-world problems, SCF07 (Latin*x*) called them "*world problems*" and SCF02 (Latin*x*) explained that the "*...connection between real-world issues other than 'bob bought 20 watermelons and gave 3 away' was helpful because, before I would just learn to get through a test, but the connection made me want to retain that information."* This notion by SCF02 (Latin*x*) was also articulated by three other participants. WF02 (White) shared that the use of real-world examples allowed her to "*...connect, like when we talked about mental illness or medical marijuana, I could connect back to that math that we learned about.*" WM06 (White) phrased it as, *"It made the subject matter more…like more memorable. So I think that definitely helps the learning process."*

Three participants reported that culturally relevant real-world examples supported their learning because the examples provided them with confidence in transferring that knowledge to other situations. Five participants mentioned that they preferred learning with real-world examples because it put meaning to the numbers; otherwise, mathematics becomes pointless. Additionally, two participants appreciated real-world examples because it exposed them to issues that they did not know or would not normally discuss. WM04 (White) summarized:

> I wish every class was like this, where…you introduce a real world issue or something that everyone can relate to, then figure it out. Not only just the math part of it or the science part of it or the English part of it… you [also] figure out the cultural part of it that's going on. I think it's going to make classes a lot more interesting.

One participant (WM01 - White) who disliked the culturally relevant real-world applications clarified that, for him, real-world applications, **"…** *just didn't help, like reaffirm stuff…it was interesting…but it's like I understand more from notes and practice."*

The participants' characterizations of the real-world problems resembled the critical elements of CRP. That is, these problems promoted informative debates and one's orientation in such debates was highly dependent on their culture or interests. The real-world problems were built around culturally relevant topics and so the participants were using “real-world problems” as a euphemism for CRP. Furthermore, the questionnaire revealed that participants deemed real-world examples to be effective, as long as they were complex (no right or wrong answer) and were based on issues that mattered to the students. In other words, the real-world examples were effective if they had a CRP focus to them.

General evaluation of prejudice reduction. According to Hernandez et al.’s (2013) CRSMT model, prejudice reduction focuses on language support, positive student to student interactions, and a safe learning environment. All participants in the study were fluent in English, so language support was not considered in the CRP Learning Modules. Participants described the learning space as being interactive, comfortable, and having a small class size. The interviews provided more detail on these ideas. For example, SCF07 (Latin*x*) expressed that the small class size alleviated “*the peer pressure of being judged*.” SCF06 (Latin*x*) stated, “*I felt very very welcomed and understood. I feel like when you're in a big class, you don't really know who you're with. But, like, being with people of your own background, you feel comfortable and just happy.”* Two other participants (SCM01 - Latin*x* and WM06 - White) believed it was the live stream, as a learning environment, that made participants comfortable.

SCM02 (Latin*x*) attributed the positive learning environment to how his peers behaved. He noted that, *“Everyone was so kind and respectful with everybody's culture. The classes always made me feel welcomed. Sadly, you don't get that from all classes...It's really sad now that I think about it.”* SCF03 (Black) agreed with SCM02 (Latin*x*) and recalled a discussion on Colorado’s racial disparities in marijuana arrests after legalization. SCF03 (Black) could sense that her classmates really cared about this issue and wanted to improve it. She expressed that this created a sense of camaraderie within the group regardless of race or culture. WM02 (White), described the learning space as being "*...like a social studies, almost, kind of class, with math kind of in, like, intervened with it."* Other descriptors that were often used for the learning space were, "*fun*" (WM01 - White), "*open-dialogue*" (WM03 - White), "*friendly*" (WM01 - White), "*inclusive*" (WM06 - White), and "*non-hostile*" (MW06 - White).

Another component of prejudice reduction is student-student interactions. Twelve of 19 participants discussed student-student interactions as positive and safe. Particularly, they mentioned that learning from others' perspectives made the Learning Modules enjoyable. For example, WM06 (White) said, "*I will look back on this experience fondly because the discussions we had related to math were inspiring. It was interesting to see how opinions on the subject matter were different based on demographic and location of my peers.*" WF01 (White) went further and elaborated that, "*It was nice to hear everyone's views but not feel judged if you did not agree with one statement or the other."* SCF07 (Latin*x*) had a similar perspective to WF01 (White) but SCF05 (Latin*x*) was somewhat different. She (SCF05 - Latin*x*) admired the intelligence of another participant (SCM02 - Latin*x*) and that pushed her to work harder and challenge herself.

Participants also noticed that the group was more diverse (racially and culturally) than the general population in Utah, where the study was conducted. This diversity brought a variety of perspectives during the student-to-student interactions. For example, WM06 (White) referred to a discussion on interracial relationships and remembered

WM03 (White) saying that his girlfriend was Black and SCF03 (Black) confessing that her parents would have a problem if she dated a White man. Another appreciation of diversity came from WM05 (White). He asserted that he was Mormon and he stated that, *"The majority here in Utah is Mormon. And so everywhere you go, you kind of find the mass majority is kind of similar in thinking. But to be around a lot of people who are of different mindsets was cool… eye opening.*" Diversity, in culture and thought, was identified by seven participants as a tool to learn, even beyond mathematics.

General evaluation of academic development. Participants compared the modules to their previous mathematics classes, and they all recognized the modules were different. Despite the issues that were identified as ineffective and the short exposure to the modules, all participants preferred the modules over the traditional mathematics courses they experienced before the class. They described features foundational to CRP as the most different and influential in their learning. Particularly, all participants identified the real-world applications and the presence of culture as the main difference between the CRP modules and a traditional mathematics class. One participant (WM03 - White) described, "*It wasn't just like, hey, how are we going to build this building? It was literally, how are we going to solve gentrification?"* WM04 (White) emphasized that the real-world examples were being related "*…to something that we enjoy… instead of whatever, like some truck has five apples or whatever."*

Identifying social issues that would resonate with participants' interests and culture is one of the guiding principles of CRP. Participants constantly referred to this feature. For example, SCF02 (Latin*x*) explained it as, *"This class put meaning to the* *numbers*." Two participants shared that, "*It felt personal*" (SCF05 - Latin*x*), and the modules "… *give me a REASON to care. Other classes don't*" (WM03 - White). WM06 (White) noted the difference was that *"There was more ethical debate related to mathematics given the real world applications."* Additionally, these debates were focused on current events rather than "*…really random [case] studies from like, I don't know, 90s, early 2000s*." Another difference that was identified by SCF01 (Black) was how the modules were conducted and the learning environment they created. SCF01 (Black) specified, "*I didn't think it was boring like a regular math class and I liked how interactive it was*." SCF01 (Black) continued that it was "*…more personal in a way, like in math class, teachers are just standing there, teaching us…, but you wanted us to contribute to it and talk and just hear from everybody.*"

The classroom conversations were also referred to by four other participants. WM06 (White) described that in a "…*traditional math class, you don't usually get into … debating in class. … It was definitely something where we were able to, kind of, open up a little bit and learn more about our fellow students*." However, SCM01's (Latin*x*) reason for preferring the modules over other mathematics classes was focused on how access was promoted. Specifically, the ease in accessing the modules through MS Teams was enough for him to prefer the CRP modules. Eleven out of 19 participants shared that MS Teams was convenient, promoted access, and helped them to learn. SCM01 (Latin*x*) expounded that MS Teams *"… makes it super easy and a first choice over something I'd have to pay for. Plus Microsoft Teams is so easy to get on a mobile device so you never miss a beat.*" SCF05 (Latin*x*) added that MS Teams "*…makes the students feel like* *they're still somewhat in school even though it's all online*." However, technical difficulties, such as disruptions with WIFI connections (SCM01- Latin*x* and WM02 - White), screen freezing (SCF01 - Latin*x*), and videos buffering (SCM01 - Latin*x*), were mentioned as impediments to learning.

Out of all of the learning aids used in the Learning Modules (e.g., example problems, practice problems, videos, and case studies), 18 participants identified the videos that introduced the culturally relevant case studies to be the most effective in their learning. WM04 (White) elaborated: "*I really liked the method of watching the real-world video…and then doing math to figure out the problem from the video…this was actually useful*." WF03 (White) shared that she *"…did mark…some of the videos that we watched to like show a friend. So that was really nice…it was the TED talk about…mental health.*" WF02 (White) was the only participant that did not like the use of videos as an instructional technique. She specified, "*I do like videos, but I feel like I zoned out…I like to be explained things, like every little information…I'd rather have you tell it to me than watch a video*." All of these instructional techniques were described as different from a traditional mathematics class. These techniques align with CRP and 18 participants credited them for fostering higher levels of engagement during the modules.

General evaluation of social justice. Participants' reviews on the instructor's willingness to act as an agent of change were minimal. However, the CRP Learning Modules did encourage the participants to challenge the status quo to develop sociopolitical or critical consciousness. For example, when the issue of gentrification was discussed, 10 participants took a stance against it and went further to assess how improvements could be made. SCF02 (Latin*x*) explained, "*Misplacing people for money is only good for the few and not for everyone. The locals should be uplifted and funded so they can move up to the level of someone who can afford to live in housing when it becomes more expensive*." SCF05 (Latin*x*) hinted at a problem that has plagued America since its founding. She stated, "*The people usually affected by gentrification are minorities and POC [People of Color]. There's a reason why they want to basically kick all these people out in the first place*." After pressing her for a solution to gentrification, she remained cautious, but pointed out that the problem is rooted in racial issues and that is where one should begin finding solutions. WM03 (White), who was also against gentrification, proposed a solution that focused on "*…increasing lower-class wages and supporting the lowest class of the economy.*" He was convinced that this would *"…stimulate it [local economy] in turn as it allows them to become more active members of the economy, opposed to the more upper-middle-class tech workers/gentrifiers who are already well off enough to put money into savings.*"

WM05 (White) and WM06 (White) were advocates of gentrification and in their analysis, they too offered a solution. They first conceived gentrification as "revitalizing" a community, so it conforms to a middle-class state. WM06 (White) elaborated that, "*I think all neighborhoods regardless of race, through the passing of time, will experience gentrification at some point.*" He continued that, "*The best way to combat gentrification is on a personal level. It's not the developers or industry's fault that things change. But lack of personal education and personal development causes displacement from a community."* WM06 (White) elaborated further:

> I've experienced this in Utah and decided if I was going to stay in the state I was born and raised in, I needed a degree to help me secure a higher paying job and the lifestyle I want for myself and family. In a way, gentrification is the reason I went back to school. But I don't think it's a developer or tech company's responsibility to increase my education. That decision has to be made personally.

Three other participants (WM01 - White, WM04 - White, and WM02 - White) had similar sentiments, dubbing gentrification as the natural evolution of a locale, however, they emphasized that it needs to be done right. WM04 (White) stated that he would hold local governments responsible in putting *"…opportunities in place for the existing culture to have a chance to be able to evolve as well, through schooling, or jobs, salary increases, tax breaks, etc."* Another participant (WM07 - White) believed gentrification "*…can clean up communities and provide nicer housing and things of that nature."*

Some participants remained on the fence on these discussions (e.g., WF02 - White and WF01 - White), but after experiencing the CRP modules, all participants admitted the desire to learn more and take a stand for or against the issues. Participants in this study completed the CRP Learning Modules just after the killings of George Floyd and Breonna Taylor in Spring 2020 - a time when racial tensions in America were high. Upon sharing Colorado's racial disparities in marijuana arrests, SCF05 (Latin*x*) strongly suggested to "*defund the police.*" She went on to explain:

> Police have always taken advantage of their power against minorities such as Black people and Latinos. Marijuana was made legal in Colorado. Why were more People of Color arrested? The thing with all of that is that it was proven that it was mostly Latin and Black people, but for White people, they were let on freebies. Police see any little thing a minority can be charged for and take it to full effect. The "justice" system is rigged and it's out to get People of Color more than Whites. People say it's not and blah blah blah, but in all honesty, if it wasn't, why are Black people getting life sentences and Latinos getting deported or getting long sentences too, but White people only get a slap on the wrist. Marijuana is everywhere, everyone knows it. People shouldn't be going to jail for it because

one way or another, it's still going to be sold.

Another participant (WM06 - White) shared that he was "…*deeply alarmed…Any state where recreational use is no longer a criminal offence should not see ANY increase in arrests for something that's now deemed legal. An increase of over 50% arrests regardless of race is unacceptable.*" WM03 (White) was more cautious of forming an opinion. He stated:

> I legitimately refuse to make a specific opinion…because I don't feel that I have the entire picture…it could legitimately come from a propensity to still use illegally sold marijuana, or a rise in underage marijuana usage…Who knows? It's a tricky situation and requires a steady, calculated response.

Several participants, including WM03 (White), WF01 (White), WF03 (White), and WM06 (White), went beyond the CRP modules and investigated more on these issues in order to formulate an opinion. The instructor (and the CRP guidelines) encouraged this and was transparent with his opinions. For example, the instructor confessed to the class that he participated in the George Floyd protests and will go to more protests. This caused three participants (all Students of Color) to vow to protest as well. Five participants (both Students of Color and White) promised to vote in the 2020 elections and pick candidates that would represent their position on the issues discussed. Some remained on the fence but confessed to having a burning desire to learn more.

Participants' Responses Based on Two Subgroups (Students of Color and White)

The following section presents patterns based on subgroups as participants commented on the general evaluation of the Learning Modules (RQ 2) and what supported or hindered their learning (RQ 3). Participants' responses are organized according to Hernandez et al.'s (2013) CRSMT model.

Content integration **based on two subgroups**. Participants' responses based on their racial/ethnic subgroups were not entirely different. However, there were some themes that appeared when students discussed how mathematics was applied to the real world and culture. The use of real-world examples and the presence of culture were prominent features of CRP. When referring to the CRP features, Students of Color (e.g., SCM02 - Latin*x*, SCF01 - Latin*x*, and SCF02 - Latin*x*) spoke about being motivated, engaged, and finding themselves caring for what was being taught. Furthermore, Students of Color were twice as likely (relative to White participants) to discuss feelings of being included during the learning process. This is a goal the CRP Learning Modules aimed to achieve by introducing mathematics that was fused with social issues that were current, controversial, and elicited participants to speak from their cultural backgrounds. One Student of Color (SCF05 - Latin*x*) confessed that she did not know mathematics could be taught in this manner.

For the White participants, their response was more about how other participants, especially the comments from Students of Color, caused them to assess their own White culture and perspectives. For example, such comments were often heard:

- "*And it helped me understand people's point of view*" (WM07 - White).
- "*It was nice seeing, like everyone's point of view*" (WF03 - White).
- "*The most interesting thing for me was hearing other people's insights*" (WM06 - White).
- "*I think that was kind of helpful to hear different perspectives*" (WF01 - White).
- "*…got me thinking about their opinions and about my own…"* (WF02 - White).

It is through this reflection that White participants tended to say they were learning from others and that learning, in this CRP environment, was broadening their perspective (e.g., WM02 - White, WF02 - White, and WF01- White). Within this notion of how mathematics was applied to the real world and culture, WM03 (White) and WM06 (White) were the only White participants that had comments similar to those of Students of Color. It is also important to note that there were two participants who said the presence of culture in the modules did not affect their learning. Those participants were White.

Another theme that appeared in participants' responses, based on subgroups, was particularly focused on instructor-student interactions. White participants mainly addressed the skills of the instructor, while Students of Color focused on how the instructor made them feel. For example, White participants discussed how the instructor was able to explain concepts clearly and effectively (e.g., WM01 - White, WF01 -White, and WM05 -White). White participants also mentioned that the instructor was professional, was able to navigate difficult conversations without aggravating anyone (e.g., WM05 - White and WM06 - White), and that they learned the instructor's stance when he spoke (e.g., WF02 - White and WM03 - White). In contrast, when speaking about the instructor-student interactions, Students of Color expressed that they felt listened to and encouraged (e.g., SCM02 - Latin*x* and SCM01 - Latin*x*). One Student of Color (SCF05 - Latin*x*) elaborated that she *"…felt very, very welcomed and understood*," and she connected to the instructor through similar interests and perspectives. While there were overlaps between subgroup responses, especially in how the instructor taught, White participants mentioned the instructor's skills three times more frequently than Students of Color.

Facilitating knowledge construction **based on two subgroups**. Regardless of the subgroup, all participants, except one, identified the use of culturally relevant, real-world examples to be an effective part of the CRP modules. The one participant who disliked the examples (WM01 - White) expressed that real-world examples "**…** *just didn't help like reaffirm stuff…it was interesting…but it's like I understand more from notes and practice*." The other 18 participants shared that real-world examples were effective because they were meaningful and they promoted understanding. However, it was Students of Color who were more likely to report that the real-world examples were meaningful. Specifically, seven of the nine Students of Color discussed the usefulness of real-world examples and the remaining two discussed how the examples promoted understanding. SCF01 (Latin*x*) explained, "*…just talking about the statistics…like discrimination is a big thing right now…I think I was able to connect that to my life a lot and with things that have happened to my family*." For White participants, three spoke to real-world examples being meaningful and the other seven found them to promote understanding.

Prejudice reduction **based on the two subgroups**. The learning space and student-to-student interactions were discussed under prejudice reduction. There was one particular theme to how the two subgroups described those discussions. When Students of Color talked about the learning space and interactions, they expressed a lessened fear of being judged. White participants' descriptions were more focused on feeling comfortable – a sense that, in those difficult conversations, there was no hostility or blame directed towards them. Furthermore, two Students of Color noticed that there were no "cliques." SCF05 (Latin*x*) shared that the CRP modules felt like *"…we were all in this together*."

Academic development **based on two subgroups**. Because of the CRP instructional techniques, all participants, regardless of race/ethnicity, preferred the Learning Modules over traditional mathematics classes. The only issues that could be classified based on subgroups were participants' recommendations and the use of technology as an instructional method. Table 7 shows the results of the final four Likert scale questions on the questionnaire. From this table it is important to note that only White participants (WM02 - White, WM05 - White, and WF03 -White) labeled MS Teams as poor.

Table 7

Summary of Responses from the Likert Scale Portion of the Questionnaire

Questions	Strongly Agree	Agree	Disagree	Strongly Disagree
1. Did you find the mathematics to be relevant?	6	12	1	
2. I would recommend these Learning Modules to my friend who is learning mathematics?	10	9		
	Very Good	Good	Poor	Very Poor
3. How was the pace of the Learning Modules?	11	8		
4. How was the usability of Microsoft Teams?	5	11	3	

More White participants (WM02 - White, WM05 - White, WF02 - White, and WM01 - White) than Students of Color (SCF03 - Black) suggested that the modules be face-to-face. Two White participants also recommended that the Learning Modules be coupled with homework assignments because this would have helped them retain more of the learned concepts. They also emphasized that the homework assignments be designed with CRP. Three Students of Color suggested that more time should have been spent on the culturally relevant case studies.

Social justice based on two subgroups. In the mathematical concepts and social issues that were presented in the CRP modules, Students of Color were more prepared to pick a stance in the moment than White participants. For example, in the case of gentrification, 9 of the 10 participants that were against it were Students of Color. The tenth participant was WM03 (White; participant who previously shared that his girlfriend was Black) and his perceptions and proposed solutions throughout the modules tended to align with those of the Students of Color. With this group of participants, it appeared that they were already informed or witnessed the social issues that were discussed. They just did not know, for example, that the topic was called gentrification, and the biggest surprise for them was to see it in a mathematics class. For the White participants, some appeared unaware of the social issues in the modules, and therefore, requested more time to learn and ascertain their stance.

The other White participants were against the perceptions and solutions proposed by the Students of Color. In the case of gentrification, nine White participants tended to assume “the systems” (social, economic, justice, etc.) were impartial and one only needs to pull themselves up by their bootstraps to succeed. Conversely, the solutions proposed by Students of Color tended to fundamentally assume that the system was rigged and there was an external force/community where power resided. For example, the proposed solutions by Students of Color had notions like, "*local communities should be empowered by…*," "*they want to basically kick out all these people…,*" and "*…it's out to get People of Color….*" Furthermore, when White participants said gentrification can "revitalize" or "clean-up" communities, Students of Color tended to rebut this assertion by questioning "who" deemed their communities stale or dirty, and to "whose" standard should their communities measure up? It is from these viewpoints that the two subgroups challenged and developed solutions for the social issues that CRP presented.

Mixed Methods Results

This section addresses the overarching question on how CRP Learning Modules supported participants' mathematics learning. This will be done by reviewing the meta-inferences from both the quantitative and qualitative results. That is, the participants' scores and evaluations of the modules were merged to answer the overarching question. The convergent results (i.e., results that are common in quantitative and qualitative results) are presented first followed by divergent results (i.e., results observed in only quantitative or qualitative results).

Convergent Results

The first meta-inference was the positive impact of the CRP Modules on participants' performance and perceptions. A majority of the participants (15 out of 19) demonstrated significant improvement in their test scores, and they had positive reviews and a sense of enjoyment when they experienced the CRP modules. The quantitative and qualitative indicators seem to strongly suggest that CRP was an effective instructional method in mathematics for these participants.

The second meta-inference is associated with the subgroups (Students of Color and White). Based on the quantitative data, both Students of Color and White participants' performance significantly increased. In addition, both subgroups had positive reviews about the CRP Learning Modules. Therefore, the quantitative and qualitative results seem to suggest that CRP was an effective instructional method for most of the Students of Color and White participants in the study.

Divergent Results

There were three meta-inferences that appeared to be divergent based on the quantitative and qualitative results. The meta-inferences are connected to those who experienced a decline in performance, yet they had positive reviews of the CRP modules. Specifically, there were four participants (WM06 - White, WM02 - White, WF03 - White, and SCF04 - Black) who had a prescore higher than their postscore. However, when analyzing the qualitative results, these participants generally had positive reviews of the CRP Learning Modules. The positive reviews appeared across all the five principles of Hernandez et al.'s (2013) CRSMT model: content integration, facilitating knowledge construction, prejudice reduction, social justice, and academic development. Thus, while some participants may have enjoyed learning from the CRP modules, their enjoyment did not have a positive effect on their posttest performance.

The second meta-inference has to do with the size of improvement in performance scores. While most Students of Color and White participants improved their scores, the biggest gains appeared for Students of Color. The third meta-inference is associated with participants' performance and principal features of the CRP modules. Particularly, the qualitative results showed that two participants (WM05 - White and WM01 - White) had unimpressed reviews on the presence of culture (WM05 - White) and real-world applications (WM01 - White) in the modules (Note: In Hernandez et al.'s (2013) CRSMT model, the presence of culture and real-world applications fell under content integration and facilitating knowledge construction, respectively). Yet, quantitative results revealed that these participants' performance increased between the pretest and posttest. The qualitative and quantitative results indicate that, while it was possible that participants may not enjoy learning with the CRP modules, they were still able to demonstrate gains in understanding the mathematics material in the modules.

Summary

This chapter produced several important results. The quantitative analysis revealed that the CRP modules facilitated statistically significant performance increases for most participants. Additionally, Students of Color demonstrated higher gains in performance that were statistically significant when compared to White students. Overall, participants identified the following as effective in their learning process while using CRP: the presence of culture and how it motivated participants to learn, the use of real-world examples that were culturally relevant, the instructors' ability to manage difficult conversations and his participation in those conversations as a student, an interactive learning space where participants learned from different perspectives especially from Students' of Color perspectives, and CRP's encouragement to develop a stance and challenge or support the discussed social issues. Because of these CRP features, the participants preferred learning mathematics with CRP over traditional methods.

In terms of the results based on subgroups, Students of Color were more likely than White students to report mitigated fears of being judged in class, feelings of motivation and caring for the culturally relevant topics, feelings of being listened to, feelings of being included in the learning process, and a connection to the instructor through similar interests and perspectives. For White participants, rather than expressing a connection to the instructor, they were more focused on applauding the instructor's skills. The culturally relevant topics that addressed racial disparities seemed to surprise them. They were also more likely to report that they learned from hearing what Students' of Color had to say and they had a higher curiosity (than Students of Color) to better understand the social issues that were discussed.

CHAPTER V

DISCUSSION

The purpose of this study was to explore the use of CRP in an undergraduate mathematics course as a way to address racial disparities in mathematics learning. CRP seeks to integrate and reflect students' interests, cultures, and backgrounds within the mathematics curriculum. CRP is typically used with ethnic/racial groups that are usually marginalized and underrepresented in education (Alismail, 2016; Bonner & Adams, 2012). As previously discussed, the needs of mainstream race/culture students are typically embedded in educational programs.

In this study, the researcher designed three undergraduate mathematics Learning Modules using CRP as a framework and those modules covered intermediate algebra topics. The overarching research question was: How does the use of CRP in undergraduate mathematics Learning Modules support students' mathematics learning? The researcher collected data on students' performance and opinions about the use of the Learning Modules. This chapter first presents a discussion on participants' performance after experiencing the CRP Learning Modules and how that change appeared in subgroups (Students of Color and White). Then the chapter presents a discussion on participants' evaluation of the modules and what supported or hindered their individual learning. The last section presents the limitations of the study and offers recommendations for future research.

Mathematics Performance Scores After Using the Culturally Relevant Pedagogy Mathematics Learning Modules

The first RQ examined participants' performance scores after using the CRP Learning Modules. A majority of the participants' improved in their performance and that improvement was statistically significant. Only four participants declined in performance. This suggests that the CRP Learning Modules had a positive impact on the participants' in this study, regardless of race. These results are consistent with numerous studies that have reported that CRP can successfully be implemented in a mathematics classroom (Aguirre & del Rosario Zavala, 2013; Brown-Jeffy, 2009; Hernandez et al. 2013; Jackson, 2013; Leonard & Moore, 2014). Apart from implementation, this study also validates the notion that CRP promotes academic achievement (Christianakis, 2011; Ensign, 2003; Gutstein, 2003; Rodriguez et al., 2004; Tate, 1995). The inclusion of students' cultural references supported mathematics performance, yet educators often refrain from using those references (e.g., Leonard & Moore, 2014; Simic-Muller et al., 2015). One reason for not practicing CRP is that many educators claim there are no CRP models to emulate in mathematics classrooms (Ukpokodu, 2011). This study offered a model, together with some specific examples, of culturally relevant topics that were meaningful to the Students of Color and White students who participated in this study.

The results comparing participants' performance by subgroups (Students of Color and White) showed that Students of Color demonstrated higher gains, and the difference was statistically significant. One could conclude that Students of Color learned more than their White peers in these CRP Learning Modules. This notion is counter to extensive literature that shows Students of Color with lower levels of performance in mathematics than their White peers (e.g., Snyder et al., 2016). The present study demonstrates that Students of Color can excel beyond White student performance benchmarks, depending on the instructional design. The design of the CRP modules in this study integrated social issues that elicited considerations on America's racial minority communities. For example, the modules discussed racial disparities in mental health care and the cultural impact of gentrification on communities. This brought mathematical legitimacy to Students of Color by using culturally relevant topics that amplified their voices without forgetting White voices. However, some White participants believed those topics put more emphasis on Students of Color's backgrounds and thus created curriculum bias, which is known to undermine student performance (Hursh, 2007). This could be the reason why the increase in White participants' scores was less than that of Students of Color. If some White participants believed there was curriculum bias in the CRP modules, then this is evidence that mathematics is not neutral. Furthermore, centuries of White domination in mathematics curricula have created curriculum bias at an industrial scale (Battey & Leyva, 2016). It is through this same bias that today's Students of Color learn mathematics.

Reflections on Participants' Evaluations of the Learning Modules

This section presents a discussion on participants' evaluation of the modules and what supported or hindered their individual learning. Hernandez et al.'s (2013) CRSMT model is used to inform the discussion.

Content Integration and Facilitating Knowledge Construction through Cultural Representation

Apart from the positive impact on participants' performance, it was also evident that the integration of CRP in the Learning Modules promoted higher levels of engagement through broader and richer opportunities to learn mathematics. Particularly, the presence of culture, which was recognized as content integration in Hernandez et al.'s (2013) CRSMT model, was associated with higher motivation and care for mathematics. This was especially true for Students of Color, who were able to maintain their culture and rise above the negative effects of having one culture dominate the teaching and learning process. An example of such negative effects are feelings of exclusion, which usually emerge from underrepresentation of ones' background, history, or culture in the curriculum (Ladson-Billings, 1994). This is why Ladson-Billings viewed CRP as a tool that empowers students socially, intellectually, politically, and emotionally by incorporating cultural referents to develop skills, attitudes, and knowledge.

In this study, cultural representation was achieved by bringing "real-world" social issues into mathematics. The use of real-world examples is recognized as facilitating knowledge construction in Hernandez et al.'s (2013) CRSMT model. Many participants found the real-world examples to be meaningful, culturally relevant, and the most effective aspect of the Learning Modules. Students of Color seemed unsurprised by the real-world examples that were presented. For example, when it was shared in a mental health case study that racial minority children were less likely to receive a diagnosis and treatment for attention-deficit/hyperactivity disorder (ADHD; Morgan, Staff, Hillemeier, Farkas, & Maczuga, 2013), Students of Color were not astonished. To some extent, this was a confirmation that the modules were building on a world they already knew as Hernandez et al.'s CRSMT model recommended.

The use of CRP to support inclusion, and higher levels of engagement through cultural representation, has been reported in other studies (e.g., Howard, 2001; Hubert, 2014; Rubel & Chu, 2011). Unfortunately, Students of Color do not often get feelings of inclusion, engagement, motivation, and care for mathematics when it is taught through traditional methods. This was evident when SCF02 (Latin*x*) shared that, for the first time in her life, the CRP mathematics problems she was solving treated her like an adult. Many other Students of Color mentioned that the culturally relevant real-world examples felt personal. For example, SCM02 (Latin*x*) explained, *"You think of math like something ancient people from ancient Greece invented… This* [CRP mathematics] *actually speaks of me, I should care about it too."* Thus, if mathematics curriculum cares enough to include a student's culture, then that student will care to learn it.

Content Integration: Cultural Awareness as a Requisite for Positive Student-Instructor Relationships

Establishing positive student-instructor relationships is part of content integration in Hernandez et al.'s (2013) CRSMT model. These positive relationships did develop, and participants attributed them to the instructor being informed on cultural issues. In fact, Milner (2011) reported that it is necessary for an instructor to be culturally competent and caring if he or she is to connect with highly diverse learners. In this study, Students of Color often expressed feelings of being connected to the instructor through similar interests and opinions. The instructor was a person of color (Black). Several studies have shown that Students of Color tend to favor instructors of color and that association with the instructor can positively affect students' performance (Cherng & Halpin, 2016; Egalite et al., 2015). Other studies show that Latinx and Black educators have more multicultural awareness than their White counterparts and that awareness is related to better learning environments for minority students (Cherng & Davis, 2019). Congruence in racial minority status, between Students of Color and the instructor, may be another reason why Students of Color had higher performance gains than White participants. This supports the call to bring more educators of color into classrooms at all levels K-16, especially as a method to reduce the racial disparities in mathematics learning. However, this does not imply that White educators cannot be successful with the integration of CRP into mathematics instruction. The basic principle in this study is that all educators can successfully implement CRP by demonstrating cultural awareness and care for student success, regardless of race. In fact, Milner (2010) demonstrates how a White teacher developed cultural awareness and how it led the teacher to build cultural congruence with his Students of Color.

However, Irvine (2010) explained that when an instructor lacks cultural awareness and the skills to facilitate CRP, they usually resort to shallow techniques, such as use of slang and acknowledging ethnic holidays, as methods of including students' cultural references. One important and novel result in this study was that participants were able to recall shallow techniques in their previous mathematics classes as failed attempts to include cultural referents. This was mostly noted by Students of Color. Not only did the students recognize the shallowness of problems such as “Jamal/Mr. Garcia had two oranges…,” they admitted that such problems caused them to disengage. Participants in the present study appreciated the use of real-world examples that were current, culturally relevant, and genuinely provoked students to critique a social issue by using mathematics. This stresses that, while attempting to include cultural referents, one should recall that Students of Color are able to identify a shallow technique of connecting to them. The use of these techniques can cause Students of Color to disengage and, therefore, CRP can become less effective.

Instructor’s Role in Facilitating Knowledge Construction

Participants mentioned that the instructor possessed the skills to mediate difficult conversations, he showed care for the discussed topics, and care for student success. More importantly, participants identified the instructor’s willingness to participate like a student and the sincerity in his perceptions as reasons to increase their contributions during the modules. For the successful interrogation of culturally relevant topics, educators must first create learning environments that support students’ voices and perspectives. Then, within those learning environments, educators must participate in discourses by consuming information and fostering skepticism that pushes learners to construct and deconstruct information. It is through this role that the instructor in this study was able to create a positive learning environment and inspire vibrant discussions that supported students’ cultural integrity. Freire (1998), Hubert (2014), and Jackson (2013) discuss the educators’ role in CRP and those discussions align with the findings of this study.

The notion of facilitating knowledge construction was described as educators' "…ability to build on what the students know as they assist them in learning to be critical, independent thinkers who are open to other ways of knowing" (Hernandez et al.'s, 2013, p. 11). In alignment with this definition, this study assumed that the main function of the educator was to impart knowledge, cultivate critical consciousness among students, and encourage the same students to be vehicles of change. The instructor and the three CRP Learning Modules showed evidence that this function was beginning to develop among the participants. However, it was also imperative that the instructor did not serve to indoctrinate students. This is especially a concern when the instructor, an authoritative figure, also shared his perspectives on the social issues that were presented. As Hernandez et al. define knowledge construction, there must be an effort to encourage independent thought among the students even when it disagrees with the instructor. For example, the Instructor, Students of Color, and White participants, did not agree on many aspects about gentrification, but what was encouraged was that perspectives must be supported by good evidence/testimonies. The goal was to see the students become vehicles of change, but not necessarily the change envisioned by the instructor, and the instructor must be comfortable with that.

Social Justice by Developing Critical Consciousness

In this study, participants developed critical consciousness by wanting to acquire in depth understanding and to challenge social issues as they were introduced in the CRP modules. Many of the participants developed a stance on the social issues and were willing to propose and follow through with actions such as voting and protesting. This is the reason why some view learning through CRP as intellectual empowerment (Timmons-Brown & Warner, 2016). According to several studies, critical consciousness is an important and necessary outcome when CRP is implemented (Epstein et al., 2011; Martell, 2013; Morrell & Duncan-Andrade, 2002; Stovall, 2006). In this study, Students of Color developed solutions on the basic assumption that America and its institutions are biased in favor of the White community (e.g., SCF05 - Latin*x*). Mathematics gave them the language to articulate that bias. As SCF02 (Latin*x*) explained earlier, "*People listen to numbers. If I state that police are killing more People of Color than White people, people cannot see how much more. So knowing how to show that is important to get my point across."* SCF05 (Latin*x*) went further and wished to "*defund the police*" as a means to challenge bias in law enforcement.

Upon encouraging participants to find solutions to the social issues that were presented in the CRP Learning Modules, many were hesitant to consider or talk about racism as the problem. It was mostly White participants who were cautious and coy to talk about race even though the social issues were clearly based on America's racial problems. As White participants described their solutions to these issues, they often inserted the phrase: "*regardless of race*." For example, WM06 (White) explained, "*I think all neighborhoods regardless of race, through the passing of time, will experience gentrification at some point.*" The discomfort to talk about race was anticipated and the instructor employed measures, in the form of icebreaker games based on race and culture, at the beginning of the Learning Modules. However, even after the icebreakers, only Students of Color, such as SCF05 (Latin*x*) and SCF03 (Black), were candid and ready to critique the social issues as racial injustices. For example, SCF05 (Latin*x*) mentioned, "*The people usually affected by gentrification are minorities and POC [People of Color]. There's a reason why they want to basically kick all these people out in the first place.*" She was the one who also stated, "*The 'justice' system is rigged and it's out to get People of Color more than Whites.*" In an attempt to understand why White participants struggled to talk about race, DiAngelo (2018) noted, "White people in North America live in a social environment that protects and insulates them from race-based stress" (p. 55). She continued that White fragility is a condition where even small amounts of racial stress can become unbearable and thus cause defensive moves such deflection, guilt, and silence. It is important that if racial injustice is the problem, then students must be brought to the comfort level that can allow them to critique and challenge it.

Prejudice Reduction by Maintaining Cultural Integrity and Positive Attitudes Towards Others

When reporting about the learning space and peer interactions, Students of Color were more likely to share that CRP mitigated their fear of being judged. This caused them to be more vocal and the class, in general, to be very interactive. It was the presence of culture that also allowed participants to develop positive attitudes towards others. Specifically, participants shared that the presence of culture, and listening to others' views on the culturally relevant topics, was instrumental in their learning process. These results have been reported in other CRP studies (e.g., Aldana et al., 2012; Dessel et al., 2006) indicating that the presence of one's culture in the curriculum and the opportunities to learn from others, especially those from different cultures, tends to affirm positive racial/ethnic identities and develop positive attitudes towards others. Positive racial/ethnic identities are associated with improved academic achievement and persistence (Rivas-Drake et al., 2014). For that reason, Waddell (2014) explained that CRP in mathematics supports students in maintaining cultural integrity while aiming for academic excellence.

Developing positive racial/ethnic identities in Students of Color is, therefore, important because both their academic achievement and persistence in mathematics are reported to be lagging behind their White peers. By validating the cultural identities of Students of Color, the psychological threat from being negatively stereotyped is often reduced (Cohen et al., 2009). Affirming cultural identities, together with developing positive attitudes towards others, is key in prejudice reduction and heightened intergroup relations. In this study, participants showed positive attitudes towards CRP and they all, regardless of race/ethnicity, preferred learning mathematics through CRP over traditional methods of teaching mathematics. These results are similar to Hubert (2014), who worked with African American high school students. Participants' reasons for preferring CRP over traditional teaching methods were that CRP offered an opportunity to learn beyond mathematics. Hearing and valuing others' perspectives according to their cultures was at the core of preferring the CRP Learning Modules.

Limitations and Suggestions for Future Research

One of the limitations in this study is that participants' increases in performance may be due to a retest effect. It is recommended that similar studies, with larger sample sizes, be conducted to understand whether the reported findings are only unique to this study. Future studies should also consider including a control group so that performance gains can be compared to an experimental group. Furthermore, it may be informative if future studies include a multivariate linear regression model to understand which independent variables (e.g., race and prescores) are stronger predictors of postscores (dependent variable).

The Learning Modules in this study did not have homework. Future studies could consider adding homework assignments designed using CRP principles. In the present study, participants, especially White participants, were coy to talk about race. Future studies could consider more effective methods of helping all participants to be more comfortable to talk about race. It is also important to emphasize that the results in this study are particular to this small group of participants, and that these results are not meant to be generalized. The findings reported here, and similar studies on the use of CRP in mathematics, can be used to understand the potential of CRP to support students' mathematics learning.

Recommendations on the Use of Culturally Relevant Pedagogy in Undergraduate Mathematics Teaching

The Learning Modules in this study have demonstrated that CRP can be implemented in postsecondary mathematics courses. The underlying principles proposed by Ladson-Billings (1994) are still recommended: (1) there must be academic success; (2) cultural competence must be developed and preserved, and (3) there must be a critical conscious development through which the current social order can be challenged by students (Ladson-Billings, 1994). In addition to these principles, this study reveals other issues that can supplement Ladson-Billing's principles. For example, as one introduces CRP to college students, it is essential to know that these are adults who can decipher that the curriculum is trying to connect with them through cultural references. Therefore, one must not use shallow techniques because it may cause students, especially Students of Color, to disengage during the lessons. This researcher recommends the use of real-world examples that are culturally relevant, complex (no right or wrong answer), current, and genuinely provoke students to interrogate social issues through mathematics. During that interrogation, the instructor must give up some authority and participate as a student who is willing to learn from different perspectives.

Even more important, the instructor must allow independent thought while encouraging students to maintain the same willingness to learn from other perspectives. By doing so, students' cultural integrity can be preserved while creating positive learning environments and vibrant discussions. It is important to know that students' (especially Students of Color) care for mathematics is highly associated with whether or not the mathematics curriculum incorporates the students' culture, background, or interests. Apart from including students' cultural references, educators must also be culturally competent in order to develop positive relationships with Students of Color. This researcher recommends that an educator be informed on culturally relevant topics (e.g., gentrification) and how they affect different cultural groups before introducing the topics to students. Multicultural awareness can be achieved by all educators regardless of race/ ethnicity.

Summary

The purpose of this study was to understand how CRP in undergraduate mathematics Learning Modules supported students' mathematics learning. Most participants demonstrated statistically significant performance gains after experiencing the CRP Learning Modules. Students of Color outperformed White participants and that difference in performance was statistically significant. Some students who enjoyed the CRP Learning Modules did not experience gains, while other students who did not enjoy aspects of the CRP Learning Modules did experience gains. This shows that for this small group of participants, their levels of enjoyment were not a reliable indicator of performance. Participants identified that the presence of culture in the CRP Learning Modules provided richer learning experiences and allowed participants to maintain cultural integrity. The participants also identified the use of real-world examples as intriguing and meaningful, especially if they were current and complex enough to warrant informative debates. Participants found student to student interactions under CRP to be safe, positive, and they enjoyed learning from others' perspectives. Participants found the use of learning aids such as videos and case studies rooted in real data to be engaging and informative. Furthermore, participants also appreciated the encouragement to develop a stance and challenge or support the discussed social issues (e.g., gentrification).

The qualitative data analysis also examined participants' evaluation of the CRP Learning Modules based on subgroups. Students of Color were also more likely than White participants to discuss elevated feelings of motivation, feelings of being engaged and caring for the culturally relevant topics, feelings of being listened to, feelings of being included in the learning process, an elevated connection to the instructor through similar interests and perspectives, and reduced fears of being judged in class. For White participants, they were more focused on applauding the instructor's skills. The culturally relevant topics that addressed racial disparities seemed to surprise White participants. They were also more likely to report that they learned from hearing what Students' of Color had to say and they had a higher curiosity (than Students of Color) to better understand the social issues that were discussed. Regardless of race/ethnicity, all the participants preferred learning mathematics with CRP over traditional methods.

It is important to remember that America was founded by and for the "…lovely white" (Franklin, 1918, p. 224), and People of Color's inclusion in America was granted through "amendments." These amendments were also seen in America's education system, however, it served to only integrate Students of Color into Whiteness. The truth is America is not White; it is a mix of many racial and cultural groups. It is not the distinct groups that divide the country; it is the failure to revel in them that divides the country. The art of teaching must reflect America's people, that is, it should also include Students of Colors' cultures, especially in mathematics. CRP can potentially be the instructional method that leverages all students' cultural references, but CRP cannot be achieved on the basis of pronouncements. It must be practiced in mathematics classrooms and that practice should inform its evolution. This study showed that CRP can be implemented in mathematics classrooms and Students of Color can learn and perform beyond White benchmarks.

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APPENDICES

Appendix A

IRB Approval Letter

OFFICE OF RESEARCH UtahStateUniversity

Association for the Accreditation of Human Research Protection Programs, Inc. Full Accreditation

Letter of Approval

From: Melanie Domenech Rodriguez, IRB Chair

Nicole Vouvalis, IRB Director
To: ***Patricia Moyer-Packenham***
Date: ***May 26, 2020***
Protocol #: ***10996***
Title: ***EXAMINING THE U.S.E OF CULTURALLY RELEVANT PEDAGOGY IN UNDERGRADUATE MATHEMATICS LEARNING MODULES WITH STUDENTS OF COLOR***

Your proposal has been reviewed by the Institutional Review Board and is approved under expedite procedure #7 (based on the Department of Health and Human Services (DHHS) regulations for the protection of human research subjects, 45 CFR Part 46, as amended to include provisions of the Federal Policy for the Protection of Human Subjects, January 21, 2019):

> *Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication, cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.*

This study is subject to ongoing COVID-19 related restrictions. As of March 15, 2020, the IRB has temporarily paused all in person research activities, including but not limited to recruitment, informed consent, data collection and data analysis that involves personal interaction (such as member checking and meaning-making). If research cannot be paused, please file an amendment to your protocol modifying procedures that are conducted in person. The IRB will notify you when in person research activities are once again permitted.

This approval applies only to the proposal currently on file for the period of approval specified in the protocol. You will be asked to submit an annual check in around the anniversary of the date of original approval. As part of the IRB's quality assurance procedures, this research may also be randomly selected for audit. If so, you will receive a request for completion of an Audit Report form during the month of the anniversary date of original approval. If the proposal will be active for more than five years, it will undergo a full continuation review every fifth year.

Any change affecting human subjects, including extension of the expiration date, must be approved by the IRB **prior** to implementation by submitting an Amendment request. Injuries or any unanticipated problems involving risk to subjects or to others must be reported immediately to the Chair of the Institutional Review Board. If Non-U.S.U Personnel will complete work on this project, they may not begin until an External Researcher Agreement or Reliance Agreement has been fully executed by U.S.U and the appropriate Non-U.S.U entity, regardless of the protocol approval status here at U.S.U.

Prior to involving human subjects, properly executed informed consent must be obtained from each subject or from an authorized representative, and documentation of informed consent must be kept on file for at least three years after the project ends. Each subject must be furnished with a copy of the informed consent document for their personal records.

Upon receipt of this memo, you may begin your research. If you have questions, please call the IRB office at (435) 797-1821 or email to irb@usu.edu.

The IRB wishes you success with your research.

Appendix B

Linear Equations Screening Test

Linear Equations Screening Test

1. If $2(x - 5) = -11$, then $x = ?$
   a. – 1
   b. –8
   c. – 11/2
   d. –3
   e. -1/2

2. Which of following a solution of y = -2x + 7
   a. (1, 4)
   b. (2, 3)
   c. (-1, -2)
   d. (1, 5)
   e. (-2, 3)

3. What is the slope of the line with the equation $2x + 3y + 6 = 0$?
   a. -6
   b. -3
   c. -2
   d. -2/3
   e. 2/3

4. Solve for the variable: $3x - 2 = 14 - 5x$
   a. -4
   b. 8
   c. 2
   d. 0
   e. -6

5. Find the y-intercept of the line with the equation 2x + y = 5.
   A. -5
   B. -2
   C. $-\frac{1}{2}$
   D. 0
   E. 5

6. Translate to an equation: six more than the product of five and x yields twenty-six.
   a. 5(x + 6) = 26
   b. 26x + 6 = 5
   c. 5x + 26 = 6
   d. 5x + 6 = 26
   e. x + 6 = 26

7. What is the slope of the line connecting the points (2, -2) and (3, -2)?
    a. Undefined
    b. 1
    c. 0
    d. -1
    e. -4

8. The cost of manufacturing a single DVD is represented by: $y = 3x + 2$ where y is cost and x is the number of DVDs. What is the cost of manufacturing 6 DVDs?
    a. $17
    b. $2.10
    c. $3.75
    d. $5.95
    e. $20

9. What is the y and x intercepts of 3x + 4y = -12 ?
    a. Y intercept = 1, X intercept = 0
    b. Y intercept = 0, X intercept = -1
    c. Y intercept = -1, X intercept = -2
    d. Y intercept = -2, X intercept = -3
    e. Y intercept = -3, X intercept = -4

10. What is the equation of the line, in y = mx + b form, connecting points (2, - 6) and (4, 4)?
    a. $y = x - 13$
    b. y = -2x + 15
    c. $y = 5x - 16$
    d. $y = x - \frac{7}{2}$
    e. y = 2x + 16

11. Which of the following is the slope of $2y - 3x = -1$?
    a. $\frac{1}{2}$
    b. $\frac{3}{5}$
    c. $\frac{4}{3}$
    d. $\frac{3}{2}$
    e. $\frac{2}{3}$

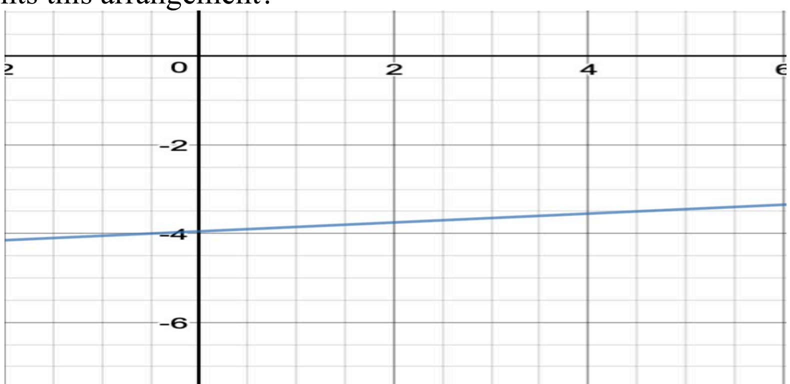
12. If $3(x + 2) = 5(x - 8)$, what is the value of x?
    a. 23
    b. 25
    c. 40
    d. 46
    e. 50

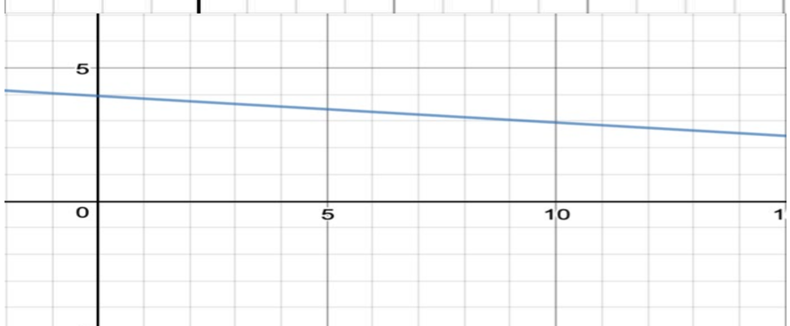
13. Which formula expresses the relationship between x and y in the table below?

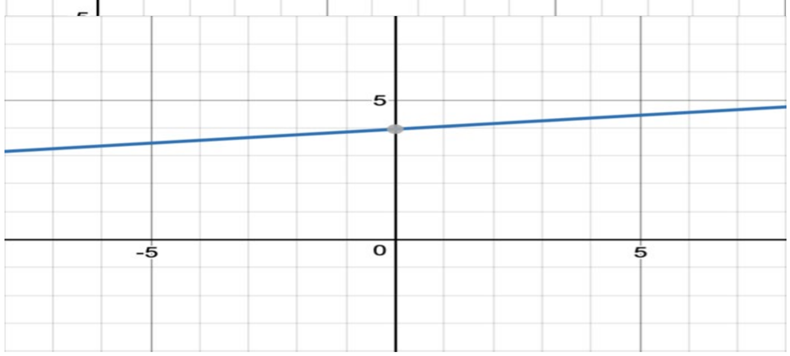
X	1	2	3	4	5
Y	-1	2	5	8	11

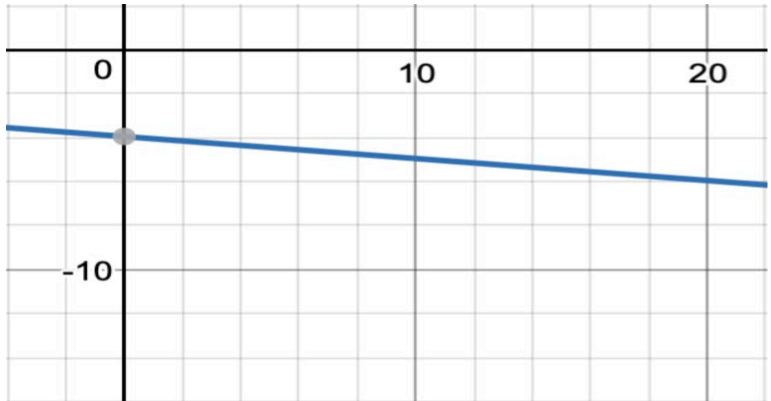
a. $Y = x + 5$
b. $Y = 2x – 4$
c. $Y = -2x + 4$
d. $Y = 3x – 4$
e. $Y = -3x – 4$

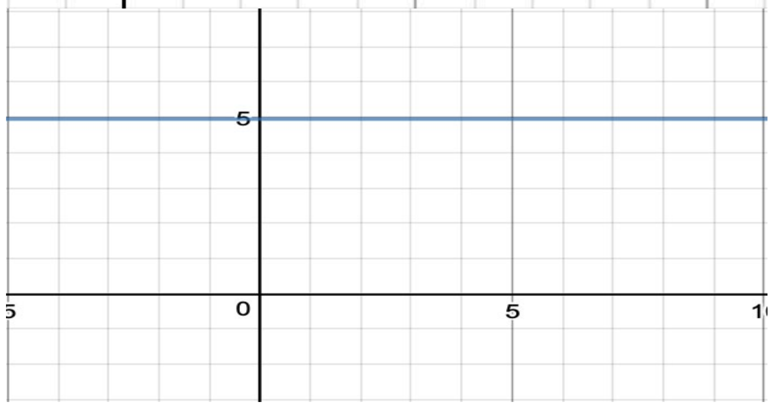
14. Your cell phone plan charges a flat fee of $4 per month for texting plus ten cents for each message sent, while received messages are free. Which graph below best represents this arrangement?

A. 

B. 

C. 

D. 

E. 

15. A negative slope means:
    a. The line is moving upward
    b. The line is moving downward
    c. The line is horizontal
    d. The line is vertical
    e. None of the above

16. Which of the following is a solution to $3x - y = 12$
    a. (0, -12)
    b. (1, 5)
    c. (3, 4)
    d. (0, 1)
    e. (1, 9)

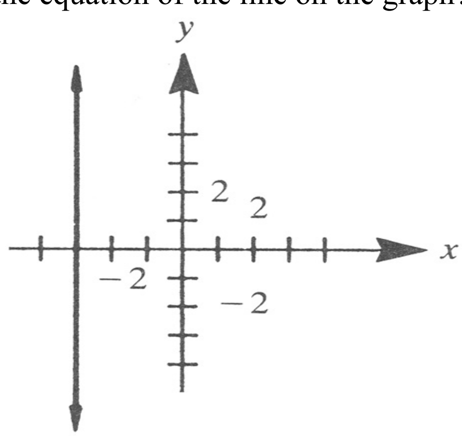
17. The adult one-day pass for Disney World is given by $y = 3x + 50$ where x is the number of years since 2000. Use the equation to predict ticket prices for 2020.
    a. \$90
    b. \$80
    c. \$70
    d. \$100
    e. \$110

18. Written in y = mx + b form, $x + y = -2$ is:
    a. $y = -5x + 10$
    b. $y = 5x - 10$
    c. $y = -x - 2$
    d. $y = -2x - 1$
    e. $y = 2x + 1$

19. The slope of a vertical line is?
    a. -1
    b. 0
    c. 100
    d. Undefined
    e. 1

20. Which of the following equations is a linear equation?
    a. $x^2 + y^2$
    b. $y = x^2 + 16$
    c. $x + y = 16$
    d. $xy^2 = 16$
    e. $x + \frac{1}{y}$

21. What is the equation of the line on the graph?



    a. $x = 3$
    b. $y = 3$
    c. $x = -2$
    d. $x=-3$
    e. $y = -3$

Appendix C

Pretest

PRETEST

Absolute Value Equations

1. What is the solution of $|2x - 1| = 7$?

    a. {0, 2}
    b. {1, 4}
    c. {2, -3}
    d. {-4, 3}
    e. {4, -3}

2. Solve for x: $|2x - 4| = -10$

    a. {-3, -7}
    b. {-3, 7}
    c. {3,-7}
    d. {3, 7}
    e. ∅

3. Solve for x: $|6x - 2| = |4x + 5|$

    a. $\{-1, 3\}$
    b. $\{-3, 1\}$
    c. $\{\frac{4}{5}, -\frac{9}{2}\}$
    d. $\{-\frac{3}{10}, \frac{7}{2}\}$
    e. $\{\frac{2}{11}, \frac{5}{21}\}$

4. Given that $-|3 - 3x| = -9$, which of the following could be a?

    a. 4
    b. 5
    c. 2
    d. 3
    e. 1

5. Solve $|3x + 2| = 0$

    a. -2
    b. ∅
    c. $-\frac{2}{3}$
    d. 3
    e. 6

6. Solve $|2x - 5| = -7$

   a. {13, -8}
   b. {12, 8}
   c. $\emptyset$
   d. {4, 5}
   e. {11,-7}

7. Write x = 6 or x = -6 as an equivalent absolute value equation

   a. |x| = 12
   b. |x| = 6
   c. |x| - 2 = 12
   d. |x| = 8
   e. $\emptyset$

Systems of Equations

8. If 4x – 3y = 10, what is the value of $12x - 9y$?

   a. 3x
   b. 3y
   c. 10
   d. 20
   e. 30

9. If $3x + 5y = 2$ and $2x - 6y = 20$, what is $5x - y$?

   a. 10
   b. 12
   c. 14
   d. 18
   e. 22

10. Solve the system: $\begin{matrix} 5x + 3y = 11 \\ 7x + 2y = 0 \end{matrix}$

   a. (4, -2)
   b. (-2, 7)
   c. (7, -3)
   d. (-2, 3)
   e. (2, -7)

11. Given: $4a + 5b - 6 = 0$ and $4a - 2b + 8 = 0$, what is the value of b

    a. -2
    b. -1/2
    c. 0
    d. ½
    e. 2

12. A movie ticket is $4 per child and $9 per adult. Today, there are 680 movie-goers and the theater collected a total of $5,235. How many movie-goers were children today?

    a. 88
    b. 112
    c. 177
    d. 368
    e. 503

13. Solve the following system: $6x + 6y = 0$
    $6x - 6y = 12$

    a. $x = 3$ and $y = -2$
    b. $x = 2$ and $y = -2$
    c. $x = 3$ and $y = 2$
    d. $x = -2$ and $y = -3$
    e. None of the above

14. For what value of a would the following system of equations have an infinite number of solutions?

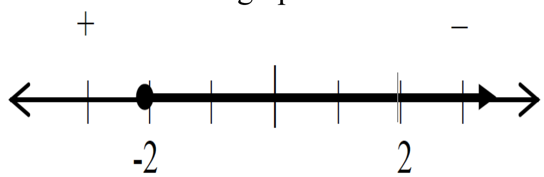
    $3x + 5y = 2$
    $9x + 15y = 3a$

    a. 4
    b. 2
    c. 3
    d. 6
    e. 9

Linear Inequalities

15. For which value of x is the inequality $-2x > 6$ true?
    a. -3
    b. -2
    c. -1
    d. 0
    e. 4

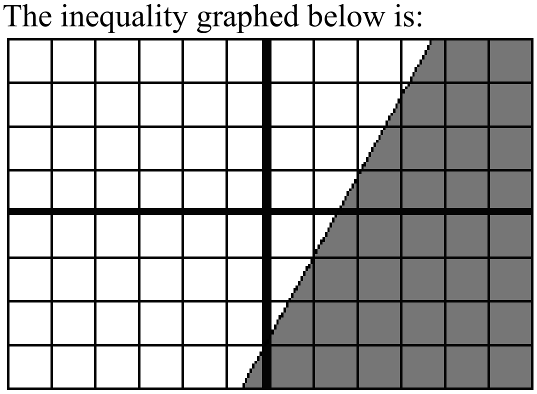
16. Which set best describes the graph below?



    a. x < -2
    b. x > -2
    c. x < -2
    d. -2 < x < 2
    e. x > -2

17. Solve for a: 3 – (a – 2) < 3 + a
    a. a < 1
    b. a < -1
    c. a = 1
    d. a > 1
    e. a > -1

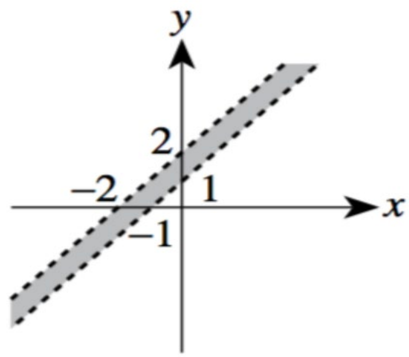
18. The inequality graphed below is:



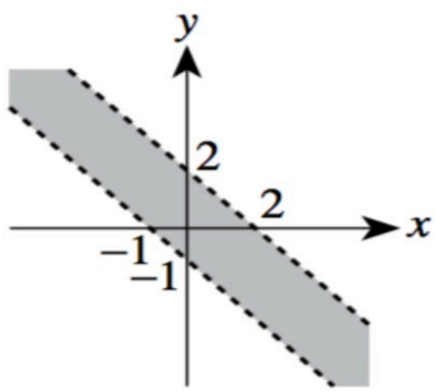
    a. $2x - y \geq 3$
    b. $x - y \geq 3$
    c. $3x + y < 3$
    d. $2x + y \geq 3$
    e. $2x - 3y > 0$

19. Which of the following is the graph of the region $1 < x + y$ and $x + y < 2$ in the standard (x,y) coordinate plane?

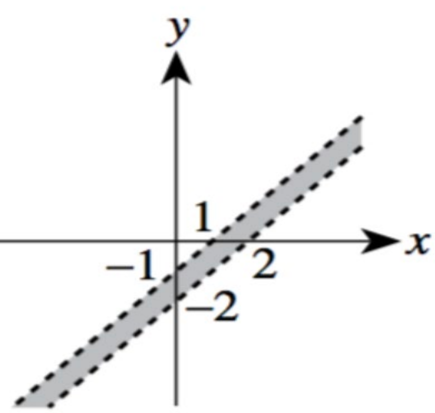
a.



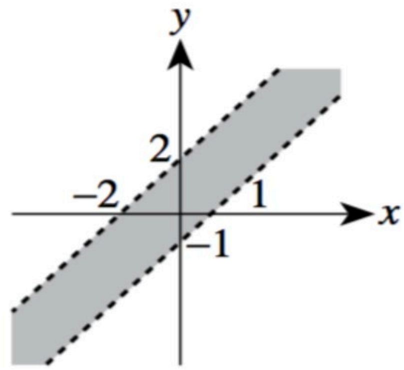
b.



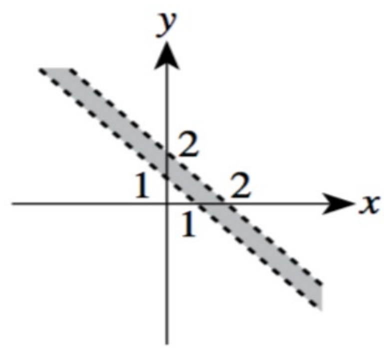
c.



d.



e.



20. Let R(t) be the revenue in the year that is t years since 2010. The model R(t) = 0.10t + 0.20 is used to predict the revenue. How many years will it take until the revenue will be more than $2.2?

    a. 11 years
    b. 20 years
    c. 22 years
    d. 10 years
    e. 30 years

21. If x and y are real numbers such that x > 1 and y < -1, then which of the following inequalities *must* be true?

    a. $\frac{x}{y} > 1$
    b. $|x| * |y| < 0$
    c. $x + 1 > y - 1$
    d. $x^2 + y^2 < 0$
    e. $x - y < 0$

Appendix D

Posttest

POSTTEST

Absolute Value Equations

1. What is the solution of $|2x + 1| = 11$?

   A. {3, 2}
   B. {1, 4}
   C. {6, 5}
   D. {-6, 5}
   E. {4, -7}

2. Solve for x: $|2x – 8| = -4$

   A. {2, 6}
   B. {-2 , -6}
   C. {0,0}
   D. {2, 7}
   E. $\emptyset$

3. Solve for x: $|5x + 1| = |3 – x|$

   A. $\{3, -1\}$
   B. $\{1, 1\}$
   C. $\{\frac{1}{3}, -1\}$
   D. $\{-\frac{1}{3}, \frac{1}{2}\}$
   E. $\{3, 2\}$

4. Given that $-2|x + 5| = -8$, which of the following could be a?

   A. -9
   B. -5
   C. 1
   D. 4
   E. -4

5. Solve $|4x + 12| = 0$

   a. -12
   b. $\emptyset$
   c. 3
   d. -3
   e. 6

6. Solve |2x + 2| = 4

    A. {5, -7}
    B. {6, -6}
    C. ∅
    D. {1, -3}
    E. {11, -7}

7. Write x = 10 or x = -10 as an equivalent absolute value equation

    A. |x| = 5
    B. |x| = 10
    C. |x| - 2 = 12
    D. |x| = 12
    E. ∅

Systems of Equations

8. If 2x + 5y = 3, what is the value of $4x + 10y$?

    A. 6x
    B. 6y
    C. 30
    D. 6
    E. 12

9. If $3x + 5y = 2$ and $2x – 6y = 20$, what is $5x – y$?

    A. -21
    B. 12
    C. 15
    D. -6
    E. -15

10. Solve the system: $\begin{aligned} -3x + y &= -3 \\ 2x + y &= 7 \end{aligned}$

    A. (9, -1)
    B. (3, 4)
    C. (5, -5)
    D. (2, 3)
    E. (-2, -9)

10. Given: $2a - b - 3 = 0$ and $8a + 4b - 12 = 0$, what is the value of b

    A. -3
    B. -1/2
    C. 0
    D. $\frac{3}{2}$
    E. 2

11. At a concession stand, three hot dogs and two hamburgers cost \$9.75; two hot dogs and three hamburgers cost \$10.25. Find the cost of one hot dog.

    A. \$2.50
    B. \$2.25
    C. \$1.75
    D. \$1.50
    E. \$1.25

13. Solve the following system: $3x + 3y = 0$
    $3x - 3y = 6$

    A. $x = \frac{6}{7}$ and $y = 1$
    B. $x = 1$ and $y = -1$
    C. $x = 1$ and $y = 4$
    D. $x = 6$ and $y = -3$
    E. None of the above

14. For what value of a would the following system of equations have an infinite number of solutions?

    $2x + 3y = 4$
    $8x + 12y = 4a$

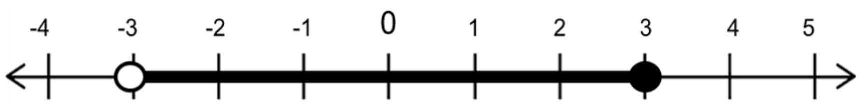
    A. -4
    B. 2
    C. 3
    D. 4
    E. 5

Linear Inequalities

15. For which value of x is the inequality $-3x \geq 12$ true?

A. -3
B. -4
C. 5
D. 0
E. 4

16. Which set best describes the graph below?

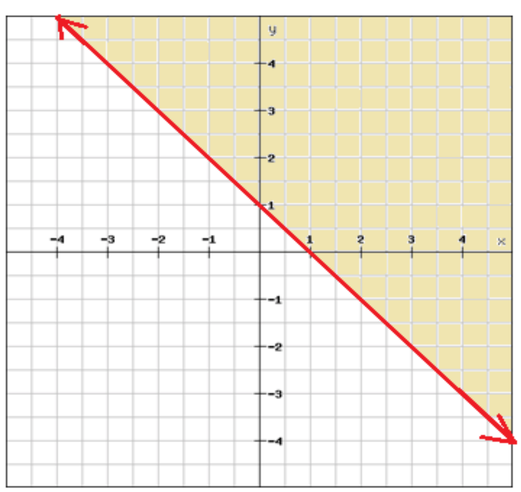


A. $-3 > x > 3$
B. $-3 < x < 3$
C. $x \leq 3$
D. $-3 < x \leq 3$
E. $x > -3$

17. Solve for a: $-(a + 5) + 3 < a$

A. $a < 1$
B. $a < -1$
C. $a = 1$
D. $a > -1$
E. $a > 1$

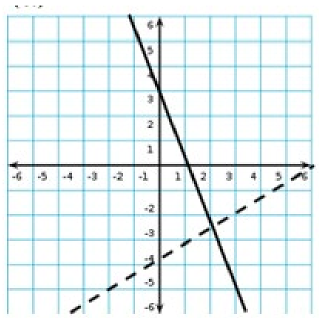
18. The inequality graphed below is:



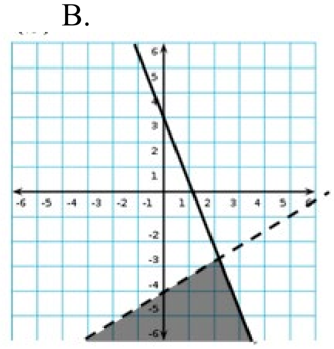
A. $x - y < 1$
B. $x - y \geq 1$
C. $x + y \geq 1$
D. $-x + y \geq 1$
E. $-x + y > 0$

19. Which of the following is the graph of the region $2x - 3y < 12$ and $y \geq -3x + 3$ in the standard (x,y) coordinate plane?

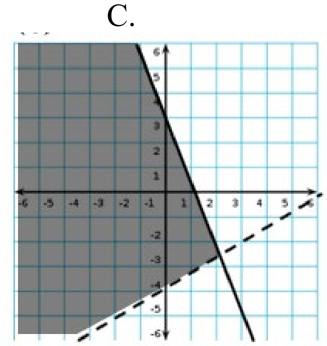
A.



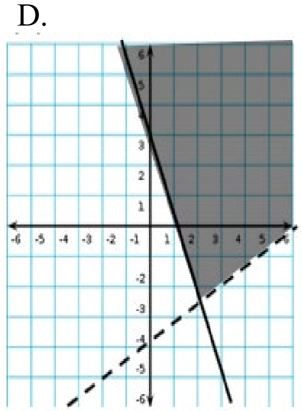
B.



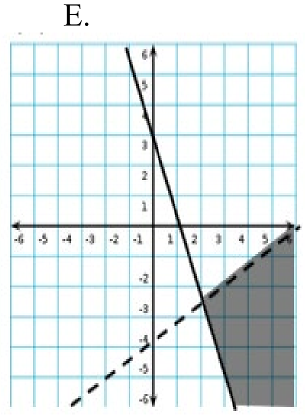
C.



D.



E.



20. Let f(t) be the sales in the year that is t years since 2010. The model f(t) = 30t – 50`1 is used to predict the revenue. How many years will it take until the sales will be more than 340 cars?

A. 11 years
B. 13 years
C. 21 years
D. 10 years
E. 30 years

21. If x and y are real numbers such that x > 2 and y < -2, then which of the following inequalities must be true?

    a. $\frac{x}{y} > 1$
    b. $|x| * |y| < 0$
    c. $x + 1 > y - 1$
    d. $x^2 + y^2 < 0$
    e. $x - y < 0$

Appendix E

Questionnaire

Questionnaire

1. What did you find different about the Learning Modules compared to prior mathematics classes you have taken?

2. What aspects of the mathematics Learning Modules did you find most effective in your learning process?

3. What aspects of the mathematics Learning Modules did you find least effective in your learning process?

4. How does the combination of mathematics and culture influence your ability to learn?

5. How does the availability of free learning tools, such as MS Teams, affect your ability to learn mathematics?

6. Describe the rigor of the Learning Modules and how this affected your learning?

7. Explain how the interactions you had with your peers affected your learning process?

8. Explain how the interactions you had with your instructor affected your learning process?

9. Why might you choose or not choose to use these modules when learning mathematics?

10. Did you find the mathematics to be relevant?

    A. Strongly Agree B. Agree C. Disagree D. Strongly Disagree

11. I would recommend these Learning Modules to my friend who is learning mathematics?

    A. Strongly Agree B. Agree C. Disagree D. Strongly Disagree

12. How was the pace of the Learning Modules?

    A. Very Good B. Good C. Poor D. Very Poor

13. How was the usability of Flipgrid?

    A. Very Good B. Good C. Poor D. Very Poor

Appendix F

Individual Interview Protocol

Individual Interview Protocol

a. Did the Learning Modules help you learn?

    a. If yes, what aspects of the Learning Modules helped you learn?
    b. If no, what aspects of the Learning Modules did not help you learn?

b. How did your unique background/identity/culture contribute to your learning process and the learning process of others?

c. What was different about learning using the modules compared to prior mathematics classes you have taken?

d. Describe the learning environment?

    a. Describe the interactions/relationship you had with the instructor as you experienced the Learning Modules?
    b. Describe the interactions/relationship you had with classmates as you experienced the Learning Modules?
    c. How did these interactions/relationships help and/or hinder your ability to learn?

e. Did you find the mathematics you learned in the modules to be meaningful? If so, how?

f. Has your attitude towards mathematics change during the Learning Modules? If so, how?

g. Describe your level of engagement during the Learning Modules. What aspect of the Learning Modules can you attribute to your level of engagement?

h. Was the time allocated to complete the Learning Modules enough?

i. Did you find your background/interests/culture represented in the Learning Modules? If yes, how was it represented and did it help you learn?

j. How did the use of Microsoft Teams compare to your previous experiences learning mathematics?

k. How useful did you find the learning aids (e.g., videos and example problems)?

l. Are there any more comments you would like to add about the Learning Modules?

m. Was there anything missing in the Learning Modules that you wish you had? And why?

Appendix G

Attribute Codes

Attribute Codes

PARTICIPANT (PSEUDONYM): *Irene*
PRETEST PERFORMANCE SCORE: *60%*
POSTTEST PERFORMANCE SCORE: *85%*
AGE: *23*
GENDER: *Female*
ETHNICITY: *Latinx*
SES: *Low*
DATE: *09/09/19*
TIME: *3:14 pm*

Appendix H

Sample Structural Coding Frame

Sample Structural Coding Frame

Research Question: What specific aspects of the Learning Modules do underrepresented participants find effective/ineffective for their learning?

Structural Code: ASPECTS IDENTIFIED AS EFFECTIVE/INEFFECTIVE

Interview questions: *see Appendix E*

Irene response: …

Appendix I

Coding Framework for Structural Coding

Coding Framework for Structural Coding

Aspects	participants comments identified as effective	participants comments identified as ineffective

CRP
• **Content Integration**
  ○ Presence of Culture
  ○ Student-teacher relationships
  ○ Learning space
  ○ Level of expectation
• **Facilitating Knowledge Construction**
  ○ Building on students' knowledge
  ○ Real-world examples
  ○ Critical independent thinking
• **Prejudice Reduction**
  ○ Native language support
  ○ Student-student interactions
  ○ Learning space
• **Social Justice**
  ○ Teacher as agent of change
  ○ Challenging the status quo
• **Academic Development**
  ○ Instructional Techniques		

Appendix J

Culturally Responsive Science and Mathematics Teaching Model

Culturally Responsive Science and Mathematics Teaching Model

<table>
<tr><th colspan="6">Content Integration</th></tr>
<tr><td colspan="2">The inclusion of content from other cultures</td><td colspan="2">The fostering of positive teacher-student relationships</td><td colspan="2">Holding high expectations</td></tr>
<tr><td colspan="2">• Incorporating information and/or examples from different cultures.
• Making connections to students' everyday lives.
• Relating teacher background to their CLD students through language and similarities in home culture.</td><td colspan="2">• Building of positive student-teacher relationships
• Building of a safe learning environment to participate in classroom discussions without fear of reprisals or negative comments from the teacher.</td><td colspan="2">• Holding high expectations for all students in the science and math classroom.
• Identifying the importance of high expectations in helping the students to achieve academically as well as socially.</td></tr>
<tr><th colspan="6">Facilitating Knowledge Construction</th></tr>
<tr><td colspan="2">Build on what the students know</td><td colspan="2">"Real world" examples</td><td colspan="2">Assist students in learning to be critical, independent thinkers who are open to other ways of knowing</td></tr>
<tr><td colspan="2">• Demonstrating the ability to build on students' background/ prior knowledge as a means to making science and math concepts accessible.</td><td colspan="2">• Using 'real world' examples during science and math lessons, especially when introducing new concepts.</td><td colspan="2">• Assisting students in effective communication.
• Motivating students to desire to learn and think independently.</td></tr>
<tr><th colspan="6">Prejudice Reduction</th></tr>
<tr><td colspan="2">The use of native language support</td><td colspan="2">Positive student-student interactions</td><td colspan="2">Safe learning environment</td></tr>
<tr><td colspan="2">• Using native language support for ELL students.
• Communicating with parents in the native language.</td><td colspan="2">• Fostering positive student-student interactions.</td><td colspan="2">• Creating a safe environment.</td></tr>
<tr><th colspan="6">Social Justice</th></tr>
<tr><td colspan="3">The teacher's willingness to act as agents of change</td><td colspan="3">Encouraging their students to question and/or challenge the status quo in order to aid them in the development of sociopolitical or critical consciousness accomplished through modeling</td></tr>
<tr><td colspan="3">• Advocating for students; act as agents of change.</td><td colspan="3">• Encouraging students to question and/or challenge the status quo.
• Assisting students in becoming good citizens.</td></tr>
<tr><th colspan="6">Academic Development</th></tr>
<tr><td colspan="3">The teacher's ability to create opportunities in the classroom that aid all students in developing as learners to achieve academic success</td><td colspan="3">The use of research-based instructional strategies that reflect the needs of a diversity of backgrounds and learning styles</td></tr>
<tr><td colspan="3">• Using a variety of methods to create learning opportunities.
• Using visuals, grouping, and hands-on or manipulatives during instruction in order to assist their students in meeting the objectives of the science and math lessons.
• Using modeling to illustrate difficult science and math concepts.</td><td colspan="3">• Using the sheltered instruction model as well as the SIOP model.
• Using real world models such as rocks, plants, clocks, etc. when introducing new or difficult concepts in science and math lessons.
• Using whole and small group collaborations.</td></tr>
</table>

Note: Acquired from Hernandez, Morales, and Shroyer (2013, p. 816, Table 2).

Appendix K

Sample Ice Breakers

Group Membership

Goal

To create a supportive environment in which the learners can disclose their group memberships and to allow them to experience what it is like to be part of a minority group.

Instructions

Have the learners form a large circle. As you call out different group names, the members are to go inside of each successive circle as they identify with the group.

Begin with "low-risk" groups (e.g. brown hair, large family, group of professions you are working with, such as a manager or production associate and then work up to groups that are typically discriminated against or under-represented (e.g. African American, Asian, female, gay, person with disabilities). Applause as each group forms in the middle

As each group of learners move towards the center of the circle, ask them what they think is the most positive thing about being a member of this group.

Discussion

- How did it feel to be in the center of the circle? (Were you comfortable being stared at?)
- How did it feel to be on the outside of the circle?
- How did you feel about those with you in the center of the circle or about those in the outer circle?
- Did anyone not make any trip into the circle? How did that feel?

I Want You To Know

Goals

To share the experiences of various ethnical, gender, religious, and cultural groups and listen to one another.

Directions:

Decide the ethnic categories to be used based on the demographics of the learners by asking the group which ethnic groups they feel comfortable using. If there is only one member of a certain group, ask if she or he feels comfortable or if she or he whishes to join another group.

Divide the group by ethnic categories and give each a sheet of flip chart paper.

Give them about ten minutes to write down their answers for the following questions:

- What we want you to know about our group.
- What we never want to see, hear or experience again as a member of this group.
- What we want our allies to do.

When all groups have completed their lists, reassemble them into one group and have them discuss their answers. When each group has explained their list, ask questions to clarify, not to challenge as the list represents realities for the group.

Discussion

- What are your initial reactions to the activity?
- Which group did you learn the most about?
- Did any of the statements surprise you?
- Did you notice any similarities between the groups?

Appendix L

Demographic Survey

Demographic Survey

Name___________________________

Student ID#__________________________

1. Do you identify as (check all that apply)
    - ☐ Male
    - ☐ Female
    - ☐ Transgender
    - ☐ Different Gender Identity:____________________
    - ☐ Prefer not to respond

2. Class Standing: What is your class standing?
    - Freshman
    - Sophomore
    - Junior
    - Senior
    - Masters/Doctoral
    - Professional Student
    - Continuing Education Student
    - Non-degree seeking

3. What is your household's estimated yearly income?
    - ☐ Less than $10,000
    - ☐ $10,000 to $14,999
    - ☐ $15,000 to $24,999
    - ☐ $25,000 to $34,999
    - ☐ $35,000 to $49,999
    - ☐ $50,000 to $74,999
    - ☐ $75,000 to $99,999
    - ☐ $100,000 to $149,999
    - ☐ $150,000 to $199,999
    - ☐ $200,000 or more

4. What languages are spoken in your home? (Mark all that apply)

    ☐ English

    ☐ Spanish

    ☐ Other (Explain)______________________________

5. How old are you?
    - ☐ 18 to 19 years
    - ☐ 20 to 24 years
    - ☐ 25 to 34 years
    - ☐ 35 or older

6. How would you identify your race/ethnicity (check all that apply)?
    - ☐ White
    - ☐ Black
    - ☐ Latino (any race)
    - ☐ Asian or Pacific Islander
    - ☐ Native American
    - ☐ White

☐ Other (Please specify): _______________________

Appendix M

Lesson Plan for Learning Module 1

Lesson Plan for Learning Module 1

Topic Introduction (Approx 30 mins**)**

Definition: Linear inequality are of the form ax + b < c, where a, b, & c are numbers and x is a variable

- They are similar to linear equations except the = is replaced by an inequality sign (<,>, $\leq, or \geq$). E.g., 2x +3 > 7.
- Linear inequalities have several applications in the real world. E.g., budget restrictions, …
- Suppose you have a budget restriction of $3000 to attend school this semester. Your cost starts with $2500 tuition and you will need to buy textbooks as well. If a textbook costs $100 on average, write a linear inequality describing the budget restriction.
    - X - # of textbooks needed
    - 100x + 2500 ≤ 3000
- If the budget is not stated then 100x + 2500 ≤ y, where y represents the budget

Graphing Linear Inequalities in one variable

< - open circle - o
> - open circle - o
≤ - closed circle - ●
≥ - closed circle – ●

Graph
X – Kanye West's height
Inequality graph

a) Kanye's height is less than 6 feet

b) Kanye's height is at least 0 feet

c) Kanye's height is more than 5 feet

d) Kanye's height is at least 5 feet
but at most 6 feet

Discovery Worksheet

1. -2 $\leq$ 4 $\frac{-2}{-2} \leq \frac{4}{-2}$ 1 $\square$ -2	*Divide both sides by -2* *Complete the box with correct inequality sign*
2. -10 $>$ -20 $\frac{-10}{-5} > \frac{-20}{-5}$ 2 $\square$ 4	*Divide both sides by -5* *Complete the box with correct inequality sign*
3. 3 $<$ 9 -3(3) $<$ -3(9) $\square$ -27	*Multiply both sides by -3* *Complete the box with correct inequality sign*
4. -2 $\geq$ -5 (-1)(-2) $\geq$ (-5)(-1) 3 $\square$ 5	*Multiply both sides by -1* *Complete the box with correct inequality sign*
	What do you notice about the inequality sign when you divide or multiply by a negative number?

Solving Linear Inequalities in one variable

- Instructor will ask students to solve – (2x - 6) ≤ 4(2x - 4) + 4 as though they were solving linear equations. The only exception is to switch direction of inequality sign when dividing or multiplying by a negative number. Then graph the solution.

Solve and graph the solution of

a) Pew Research Center shows that the number of interracial marriages in Virginia has been increasing since "loving versus Virginia." If the number of interracial marriages in 2017 is at most 200 less than six times the number of interracial marriages in 1967 ($x \leq 6x - 200$), then

- solve and graph the solution of this inequality.
- What does your solution mean?
- Quickly google "loving versus Virginia" and discuss why interracial marriages are increasing and whether your home culture is accepting of interracial marriages.

Solve and graph the solution of

Solve	*Steps*	*Graph*
	• Solve similar to Linear Equations • Flip inequality sign when dividing or multiplying by a negative number	
a) $15 + 2x \geq 4x - 7$		
b) $4x - 40 \leq 7(-2x + 2)$ $4x - 40 \leq -$ $14x + 14$ $+14x \quad +14x$ $18x - 40 \leq 14$ $+40 \quad +40$ $18x \leq 54$ $X \leq$	Distribute Add 14x on both sides Add 40 on both sides Divide 18 on both sides	
c) $3(x - 5) < 2(2x - 1)$		

Graphing Linear Inequality in 2 variables

$<$ - dotted line
$>$ - dotted line
$\leq$ - solid line
$\geq$ - solid line

Graph the budget restriction example: $100x + 2500 \leq y$
Steps:

- Ask students to graph $100x + 2500 = y$
- Instructors shows them how to shade
- Instructor asks students if a budget of 2800 is feasible given 4 textbooks have to be bought
- Instructor asks students what budget and number of textbooks are feasible

Practice Problems (in groups, approx 30 mins**)**

1. A bunch of HipHop artists such as Drake and J. Cole dropped new albums over the weekend. You want to use the $50 itunes gift card you received from Aunt May to buy some of the albums. If itunes has a one-time subscription fee of $5 and an album costs $10. Select a linear inequality to represent the budget.

   i) Which linear inequality shows the albums you can afford before over spending the amount on the gift card.
      a) $5x + 10 \leq 50$
      b) $10x + 5 \leq 50$
      c) $10x + 5 \geq 50$
      d) $10x + 50 > 5$
      e) $5x + 10 < 50$

   ii) Solve your linear inequality and graph of the solution.

2. In order to earn some extra money, Hayley drives for Uber. She makes $150 during the day and $200 during the night. She would like to make at least $3000 to cover her tuition before next semester begins.

   x = the number of days she works

   y = the number of nights she works

   i) Select a linear inequality to represent the situation.

      a) $200x + 150y \geq 3000$
      b) $150x + 200y > 3000$
      c) $150x + 200y \leq 3000$
      d) $200x + 150y > 3000$
      e) $3000x + 200y < 150$

   ii) Solve your linear inequality and graph of the solution.

3. Every time Jaden tries to study he ends up watching Key & Peele skits on YouTube and sliding into girl's DMs. One skit is 3 minutes long and it takes Jaden 5 minutes to go through pictures and send a DM. Jaden wants to spend less than 25 minutes watching skits and sending DMs so he can study.

x = the number of skits

y = the number of DMs

i) Select linear inequities that represent the situation.

a) $5y + 3x < 25$
b) $3x + 5y > 25$
c) $5y + 3x \leq 25$
d) $5y + 3x \geq 25$
e) $3x + 5y < 25$

ii) Solve your linear inequality and graph of the solution

4. Aaron and Alma are students and they are about to get married at the temple. However, Aaron is only thinking whether they can afford buying the house they want. He can work a total of not more than 20 hours per week between his two jobs. His job as a nurse aid pays him \$15 per hour and his other job at a call center pays him \$12 per hour. He needs to make at least \$120 per week in order to afford the house. and graph their intersection ("and").

X – number of hours as a nurse aid

Y – number of hours at call center

i) Write two linear inequalities to represent the situation

a) $x + y \leq 20$ and $15x + 12y \geq 120$
b) $x + y \geq 20$ and $12x + 15y \geq 120$
c) $12x + y \geq 20$ and $15y + y \geq 120$
d) $x + y < 20$ and $15x + 12y < 120$
e) $x + y > 20$ and $15x + 12y > 120$

ii) Graph of the solution

5. You are selling pizzas to raise money for your soccer/football tournament. Cheese pizza cost \$8 and pepperoni pizza cost \$9. You need to sell at least two of each kind of pizza, and you want to sell at least \$180 worth of pizza.
   x = number of cheese pizzas
   y = number of pepperoni pizzas
   $x \geq 2$, $y \geq 2$, and $8x + 9y \geq 180$

i) Graph the intersection of the three linear inequalities.

10-minute break

Case Study: Gentrification (Approx 30 mins**)**

Instructor briefly defines gentrification

Watch the following video to understand the processes of gentrification:
https://www.youtube.com/watch?v=tYNuR1oaQts

According to the census track data for U.S.' largest 50 cities, 9% of neighborhoods in these cities experienced gentrification in 1990. By the year 2000, 20% of neighborhoods experienced gentrification. The Salt Lake Tribune (05/10/2012) also reports parts of Salt Lake City (even Ogden and West Valley City) are at risk of gentrification.

Suppose the following linear inequality model predicts the percentage of neighborhoods (y) gentrified in a particular year (x):

$$y < 1.1x + 9$$

y - percentage of neighborhoods gentrified in the nation's 50 largest cities
x - number of years

Graph

a) Given the model starts from 1990, is 46% (y) in the year 2019 ($x = 29$ years) a possible solution in the model?
b) Suppose 37% of the neighborhoods in the largest 50 cities have been gentrified by the year 2019 ($x = 29$ years). Would you consider this model a good predictor of gentrification?
c) According to the model, in what year will at most 50% of the neighborhoods be gentrified?
d) In what ways could gentrification benefit your city?
e) How can gentrification hurt the local culture?
f) Knowing gentrification is occurring, what can you do to preserve existing cultures?

Instructor: Show how you could stop gentrification

Appendix N

Lesson Plan for Learning Module 2

Lesson Plan for Learning Module 2

Topic Introduction (Approx 30 mins)

Definition: A collection of 2 or more linear equations with a same set of variables.

e.g., $3x + 2y = 4$
$5x + y = 2$

Graph the equations to show a unique solution

E.g., You and your crush are heading to a Jazz versus Lakers game. Some friends insist on tagging along. You get courtside seats to impress your crush and some of her/his friends, and high-level seats to keep the loud friends away. If a total of 6 people attended the game, and each courtside seat costs $420 and each high-level seat costs $30:

a) Write a system of linear equations given you spend a total of $1350.

X - # of courtside seats
Y - # of high-level seats

$$x + y = 6$$
$$420x + 30y = 1350$$

b) How many courtside and high-level seats did you buy?

Demonstrate solving by elimination:

$$x + y = 6$$
$$420x + 30y = 1350$$

…

E.g., Adrian is choosing between 2 cell phone plans. The 1st plan costs $20 per month plus 25 cents per minute used. The 2nd plan charges $40 per month plus only 8 cents per minute used.

a) Write the linear system of equations

1st plan: $y = 0.25x + 20$
2nd plan: $y = 0.08x + 40$

b) Solve the system of equations to determine at how many minutes the plans are the same.

c) How many minutes per month do you use and which plan would be best for you?

Types of solutions in system of linear inequalities

Independent system has one solution (x, y) graph
Inconsistent system has no solution (different y-intercept but slopes are the same)
Dependent system has infinitely many solution (one equation is a multiple of the other)

	Hint	Conclusion
1 a) $2x + 3y = 5$, what is the value of $4x + 6y$? b) How many solutions does this system have: $2x + 3y = 5$ $4x + 6y = 10$ c) How does $2x + 3y = 5$ and $4x + 6y = 10$ relate?	Solve and graph them	
2a) $2x + 3y = 13$ and $4x - 5y = 4$, what is the value of $6x - 2y$? b) How many solutions does this system have: $2x + 3y = 13$ $4x - 5y = 4$	Solve and graph them	
3) $x + 7y = 1$ $-2x - 14y = a$ a) What should be the value of "a" if you want infinitely many solutions? b) What should be the value of "a" be to have no solution.	Approach it like you want to solve it	

Practice Problems (in groups, approx 30 mins**)**

1) At a college bookstore, Carla purchased a math textbook and a novel that cost a total of \$54, not including tax. If the price of the math textbook, *m*, is \$8 more than 3 times the price of the novel, *n*, which system of linear equations could be used to determine the price of each book?

2) UVU and Woodbury Corp want to develop "student housing," however, the community sees it as another "high-density housing" project. The community is against high-density housing because it increases traffic, parking issues, and crime in Orem– which is already cramped up. UVU and the developer argue that the high-density housing will increase housing availability for students and the proximity to the university will provide an on campus living experience for the students.

a) Who is right in this situation?

b) Suppose a compromise was reached. The developer will provide high density housing at \$250,000 per house and low-density housing at \$400,000 per house. There is a total of 325 houses to be developed and it will cost \$100,000,000. How many houses were high density?

3) The National Center for Health Statistics shows Provo-Orem and Seattle-Tacoma as among the metro areas with the highest rates of suicide. The total number of suicides between Provo-Orem and Seattle-Tacoma is 204 per year. Provo-Orem, P, area has 72 suicides less than twice the amount in Seattle-Tacoma, S. Write a system of linear equations that can be used to determine number of suicides in Provo-Orem and Seattle-Tacoma.

4) You are deciding between two job offers as a server. Zanzibar, the first restaurant, has a high base pay but the tips tend to be lower - \$800 plus \$10 per table you serve. Dulce Patria, the second restaurant, has a low base pay but the tips are higher - \$500 base plus \$20 per table you serve. After how many tables will you start to make more money at Dulce Patria?

Case Study: Mental Health

https://www.youtube.com/watch?v=FgNaqfGTysU
https://www.youtube.com/watch?v=oCG4l21Mexk
https://www.youtube.com/watch?v=yEaV1If18RI

Attention deficit hyperactivity disorder (ADHD) is one of the most common mental health disorders of childhood. The following system of linear equations shows percentage of children aged 5-17 years ever diagnosed with ADHD, by race and ethnicity: U.S., 1998-2009 (SOURCES: CDC/NCHS, Health Data Interactive and National Health Interview Survey).

White: 0.25x – y = -8 or $\frac{1}{4}x - y = -8$
Black: 0.45x – y = -5 or $\frac{9}{20}x - y = -5$
Hispanic: 0.15x – y = -3 or $\frac{3}{20}x - y = -3$

Y - % of children diagnosed with ADHD
X - number of years (e.g., 1998 is year 0, 1999 is year 1…)

Appendix O

Lesson Plan for Learning Module 3

Lesson Plan for Learning Module 3

Topic Introduction (Approx 30 mins)

Definition: The absolute value of a number is its distance from 0 on the number line
E.g., $|-3| = 3$
$|2| = 2$
An example of an absolute value equations: $|x| = 2$

An absolute value function can be used to show how much a value deviates from the norm.

Application 1: The average internal body temperature of humans is 98.6° F. The temperature can vary by as much as 0.5° and still be considered normal

i) Write an absolute value equation that describes the temperature
$y = |x - 98.6|$

ii) The x-axis corresponds to the temperature of the person in question. What does the y-axis represent?

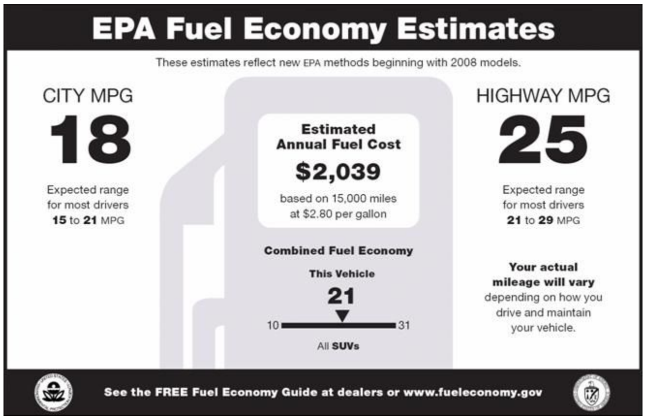
iii) Graph $y = |x - 98.6|$ (desmos)

iv) To be within humans' normal body, what would the domain and range of the function be?

v) Write the equations of the 2 lines of $y = |x - 98.6|$

Discovery Application Problems

Application 2: "EPA fuel economy estimates"



i) Write an absolute value equation that describes the car's city mile usage.
   $y = |x - 18|$

ii) The x-axis corresponds to the temperature of the person in question. What does the y-axis represent?

iii) Graph the equation $y = |x - 18|$

iv) To be within the government's estimated fuel efficiency estimates for city driving for this car, what would the domain and range of the function be?

v) Write the equations of the 2 lines that represent $y = |x - 18|$

vi) If enough claims have been reported that their vehicle is not as efficient as advertised then EPA investigations can occur and new ratings may be established

Discovery Application Problems
Write the equations of the 2 lines that represent the following equations then solve them:
i) $|x| = 2$
ii) $-2|x + 2| = -4$
iii) $|x + 7| = -3$
iv) $|4x + 2| = |3x + 6|$

Practice Problems (in groups, approx 30 mins**)**

1. i) Write an equation for the estimated highway fuel efficiency
   ii) What would the range of the function be for HIGHWAY driving?
   iii) What would the graph look like?
   iv) Write the equations of the 2 lines that represent the equation

2. On a recent outing, the car was filled with gas. Each time the tank is filled, Trip B is reset. Based on the images below, calculate the gas mileage for the previous tank of gas.

i) Was the MPG within the expected range?

ii) Was the van driven primarily in the city or on the highway?

iii) What was the cost of gas per gallon at the time it was filled?

3. Engineering Application

   Sydney Harbor Bridge in Australia is 1149 meters long. Because of changes in temperature, the bridge can expand or contract by as much as 0.42 meters. Write and solve an absolute-value equation to find the minimum and maximum lengths of the bridge.

4. Communication Application

   Alexa's walkie-talkie has a range of 2 miles. Alexa is traveling in a straight highway and is at mile marker 207. Write and solve an absolute-value equation to find the minimum and maximum mile marker from 207 that Alexa's walkie-talkie will reach.

5. Manufacturing Application

   A quality control inspector at a bolt factory examines random bolts that come off the assembly line. Any bolt whose diameter differs by more than 0.04 mm from 6.5 mm is sent back. Write and solve an absolute-value equation to find the maximum and minimum diameters of an acceptable bolt.

Case Study:

Until the passage of the 2018 U.S. farm bill, under federal law, it was illegal to possess, use, buy, sell, or cultivate cannabis in all U.S. jurisdictions, since the Controlled Substances Act of 1970 classified marijuana as a Schedule I drug, claiming it has a high potential for abuse and has no acceptable medical use. Before 2018, the FBI Uniform Crime Reporting states that Marijuana arrests in Utah were about 5876 per year. The number of arrests would vary by 183 individuals per year and still be considered normal.

a. Write and solve an absolute-value equation to find the Utah's minimum and maximum marijuana arrests per year.

b. "…has no acceptable medical use."
https://www.youtube.com/watch?v=wVlIZkbdwF4

    i. Should doctors prescribe Marijuana even though researchers are barely starting to test it?

c. What should happen to old marijuana convictions in states where it's now legal?

d. https://www.youtube.com/watch?v=Fb22aT_M_mo

    A study conducted in Colorado between 2012 and 2014, found that after the state voted to legalize marijuana in 2012, white juvenile marijuana arrests dropped by 8 percent. By contrast, black and Latino juvenile arrests shot up by 58 percent and 29 percent, respectively, over the period.

How do you explain the data above and what can be done?

CURRICULUM VITAE

THOMAS A. MGONJA
Developmental Mathematics Department, Utah Valley University
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E-mail: thomasm@uvu.edu, Tel: 305 890 9004

EDUCATION

Ph.D. April 2021
Education, Utah State University, U.S.A
Specialization: Curriculum and Instruction
Concentration: Mathematics Education and Leadership

M.S. May 2010
Master's in mathematics, Florida State University, U.S.A

B.S. May 2008
Bachelor of Science in Mathematics, Idaho State University, U.S.A

EMPLOYMENT HISTORY

UTAH VALLEY UNIVERSITY

Associate Professor, Tenured, Developmental Mathematics (2012-present).
University College, Utah Valley University.
Responsibilities include teaching both developmental and occasional college level mathematics courses, conducting scholarship work in developmental mathematics, and service at departmental, college and university levels.

SALT LAKE CITY COMMUNITY COLLEGE

Adjunct Professor, Mathematics Department (2012).
College of Arts and Sciences, Salt Lake City Community College.
Taught college level mathematics courses and involved in course development for online college algebra classes.

ARDHI UNIVERSITY

Visiting Lecturer, Civil Engineering Department (Summer 2013)
School of Architecture, Construction Economics and Management, Dar es Salaam, Tanzania.
Taught the calculus series to civil engineering students.

EVEREST COLLEGE

Statistics & Mathematics Lecturer (2010-2012)
Everest College
Taught Statistics and implemented practical training on statistical packages such as SPSS**,** also taught fundamentals of investing (Personal Finance), Probability (Risk Management), and college algebra.

ART INSTITUTE OF SALT LAKE CITY

Mathematics Lecturer (2010 – 2011)
Art Institute of Salt Lake City
Responsibilities include course development for mathematics courses and taught intermediate algebra.

IDAHO STATE UNIVERISTY

Supplemental Instruction Leader (2007-2008)
TRIO Federal Programs, Idaho State University
Mentored and assisted students to begin and complete post-secondary through Upward Bound Math-Science and Student Support Services.

UNIVERSITY TEACHING

Utah Valley University, Orem, Utah (2012-present)
University College
Courses taught – Utah Valley University
MATH 1050 – College Algebra
Includes inequalities, functions and their graphs, polynomial and rational functions, exponential and logarithmic functions, conic sections, systems of linear and nonlinear equations, matrices and determinants, arithmetic and geometric sequences, and the Binomial Theorem.

MAT 1030 – Quantitative Reasoning
Introduces major topics in the field of mathematics. Includes sets, algebra, geometry, and statistics. Emphasizes problem solving and critical thinking.

MAT 1010 – Intermediate Algebra
Expands and covers in more depth basic algebra concepts introduced in Beginning Algebra. Topics of study include linear and quadratic equations and inequalities, polynomials and rational expressions, radical and exponential expressions and equations, complex numbers, systems of linear and nonlinear equations, functions, conic sections, and real world applications of algebra.

MAT 0990 – Introductory Algebra
For students who have completed a minimum of one year of high school algebra or who lack a thorough understanding of basic algebra principles. Teaches integers, solving equations, polynomial operations, factoring polynomials, systems of equations and graphs, rational expressions, roots, radicals, complex numbers, quadratic equations and the quadratic formula. Prepares students for MAT 1010, Intermediate Algebra.

MAT 0950 – Foundations for Algebra
Designed for students requiring basic math and pre-algebra instruction. Covers basic operations for number systems up to and including real numbers. Includes fractions, ratios, proportions, decimals, exponents, roots, linear equations, and polynomial expressions.

MAT 0920 - Math Fundamentals
Designed for students requiring basic math review. Reviews basic operations with whole numbers and fractions. Topics of study include basic operations involving decimals, percents, ratios, rates, and basic operations involving physical measurements.

MAT090R – Math Pass
Designed for students who desire an interactive math course to review mathematics skills and to work towards improving placement level in preparation for Quantitative Literacy Course. Intended to use adaptive questioning to develop an individualized study plan, which includes instruction on topics students are most ready to learn.

Everest College, Salt Lake City, (2010-2012)
Courses taught – Utah Valley University
STAT 2100 – Statistics
The course teaches conceptual underpinnings of statistical methods and how to apply them to address more advanced statistical questions than are covered in an introductory statistics course. The statistical methods covered in the course are useful for many types of questions that relate to multiple variables and/or multiple groups. Learning how to effectively use data and statistical methods to make evidence-based business decisions is the overarching course goal. Statistical analyses are performed using SPSS and Excel.

SCHOLARSHIP

Research Interests:

- Impact of cultural differences in science, technology, engineering and mathematics fields
- Gender and racial-ethnic differences in mathematics education
- Comparative studies on Africa and America Mathematics learning

Peer Reviewed Publications

Mgonja, T. A. (2020, November). The Lost Voices in Mathematics Teaching, *Utah Council of Teachers of Mathematics* (pp.50-62)

Mgonja, T. A. & Chang, K.L. (2019, January). Difficulties in solving linear equations with fractions, *Utah Council of Teachers of Mathematics* (pp.13-29)

Conference Proceedings

Mgonja, T. A., Chang K.L., & McKenna, H. (2017, February). Bridging the gaps between teachers' and students' perspectives of a culturally inclusive classroom, *Proceedings of the Research in Undergraduate Mathematics Education* (pp.1645-1646), San Diego, California.

Chang, K.L., McKenna, H., & **Mgonja, T.A**. (2017, February). Diagrams for the reasoning and proof of amortization formula, *Proceedings of the Research in Undergraduate Mathematics Education* (pp.1551-1552), San Diego, California.

Works In Preparation

McKenna, H., Chang K. L., & **Mgonja, T. A.,** (2021, Spring). A Framework to Measure Microaggressions in the Mathematics Classroom. Submitted to *SN Social Sciences*.

Mgonja, T. A. & Chang, K.L. (2021, Fall). Bridging the gaps between teachers' and students' perspectives of a culturally inclusive classroom. Submitting to *The American Educational Research Association Journal.*

Mgonja, T. A. (2021, Fall). The transfer gap in solving equations containing variables only. Submitting to *The Journal for Research in Mathematics Education.*

PROFESSIONAL PAPER PRESENTATIONS AND SYMPOSIA

McKenna, H., Chang K. L., & **Mgonja, T. A.,** (2019, October). *Identifying Neo-Racism in the Classroom*. University College Conference on Student Success, Orem, Utah.

Mgonja, T. A., Chang K. L., & McKenna, H. (2017, February). *Exploring Gaps between Instructors' and Students' Perspectives of a Culturally Inclusive Classroom.* AAC&U's *2018 Diversity, Equity, and Inclusive Democracy: The Inconvenient Truths* conference, San Diego, California.

Mgonja, T. A., Chang K. L., & McKenna, H. (2017, February). *Bridging the gaps between teachers' and students' perspectives of a culturally inclusive classroom.* Research on Undergraduate Mathematics Education (RUME), San Diego, California.

Chang, K. L., McKenna, H., & **Mgonja, T. A**. (2017, February). *Diagrams for the reasoning and proof of amortization formula.* Research on Undergraduate Mathematics Education (RUME), San Diego, California.

Mgonja, T. A. & Nehring, J. V. (2016, November). *What does engaged learning look like?* Annual Conference of the Utah Council of Teachers of Mathematics (UCTM), Salt Lake City, Utah.

Mgonja, T. A. & Chang K. L. (2014, spring). *Difficulties in solving linear equations with fractions*. Southwest Association for Developmental Education, Salt Lake City, UT.

Mgonja, T. A. & K.L. Chang (2015, spring). *Fractions: Conceptual understanding versus rote learning*. Research-to-Practice Conference, Dallas, Texas.

INVITED ACADEMIC LECTURES AND ADDRESSES

Mgonja, T. A. (2017, September). *Charlottesville: Racism Reawakened* (Facilitator). Annual Ethics Awareness Conference. Utah Valley University, Orem, UT.

Mgonja, T. A. (2015, November). *Expect the great* (Panelist). African/African American Leadership Conference. Weber State University, Ogden, UT.

Mgonja, T. **A.** (2015, November). *Black youth summit* (Speaker) African/African American Youth Conference. Rowland Hall St. Marks Middle School, Salt Lake City, UT.

Mgonja, T. A. (2015, September). *Ethics of racial profiling* (Presenter). Annual Ethics Awareness Conference. Utah Valley University, Orem, UT.

Mgonja, T. A. (2015, April). *Women & minorities in science technology engineering & mathematics* (Co-Presenter). Graduate Student Research Fair, Weber State University, Ogden, UT.
Mgonja, T.A. (2014, April). *Diversity and inclusivity promo* (Presenter). Utah Valley Senior Executive Leadership Forum-UVSELF. Utah Valley University, Orem, UT

Mgonja, T. A. (2014, September). *Male of color misandry: The racialized marginalization and stigmatization of men of color* (Panelist). University of Utah, Salt Lake, UT.

Mgonja, T. A. (2014, March). *Black boys lead: Applied cultural capital*. Workshop Presented at the African/African American High School Day Conference, Salt Lake, UT.

Mgonja, T. A. (2014, February). *Examining marginalized leadership strategies of African American students attending PWIs* (Facilitator). Expect the Great Symposium, Salt Lake City Community College, Salt Lake, UT.

Mgonja, T. A. (2013, October). *Approaching a holistic pedagogy: Toward appreciating students*. Inspiring Teaching: A Conference on Transformative Education. University of Utah—MU.S.E Project keynote speech, Salt Lake, UT.

HONORS, AWARDS, AND FELLOWSHIPS

(2018) Champion of Inclusion Award. Utah Valley University, Orem Utah
(2018) Martin Luther King Fellowship (Tuition + $7000), Research & Graduate Studies. Utah State University, Logan Utah.
(2015) Phi Theta Kappa International Honor Society, Most Distinguished Regional Advisor. Rocky Mountain Cascade Region.
(2008) De Witt Sumners Award. Florida State University, Tallahassee, Florida.

SERVICE AND INVOLVEMENT

<u>Institutional</u>
(2020-21) Rank, Tenure, and Promotion Committee (member). Utah Valley University
(2020) Hiring Committee for tenure track Assistant Professor. Member. Utah Valley University
(2019) Campus Climate Assessment Committee (President's Office). Chair. Utah Valley University
(2018-19) Inclusion and Diversity Committee (President's Office). Member. Utah Valley University
(2018) Hiring Committee for Chief Inclusion & Diversity Officer (President's Office). Member. Utah Valley University
(2017) Developmental Mathematics Department Hiring Committee. Member. Utah Valley University
(2016-17) Society for Collegiate Leadership & Achievement. Advisor. Utah Valley University
(2016-17) Quantitative Literacy Research Committee. Member. Utah Valley University
(2016) Developmental Mathematics Department Hiring Committee. Member. Utah Valley University
(2015-17) The society for Collegiate Leadership & Achievement. Advisor. Utah Valley University
(2015-17) Martin Luther King Commemoration Board. Chair. Utah Valley University

(2015-17) Community Advisory Board. Liaison Officer. Provo Police Department.
(2014-17) Ethics Center Faculty Advisory Board. Member. Utah Valley University.
(2014-17) Course Fees & Tuition Review Committee. Member. Utah Valley University
(2014-17) Black Student Union. Advisor. Utah Valley University
(2013-14) Developmental Mathematics Department Evening Coordinator. Utah Valley University
(2013) Developmental Mathematics Department Hiring Committee. Chair. Utah Valley University
(2012-15) Phi Theta Kappa International Honor Society. Advisor. Utah Valley University.
(2012) Developmental Mathematics Department Textbook Selection Committee. Chair. Utah Valley University.

(2016-18) Utah Valley University's African Diaspora Initiative
Director and Cofounder, Multicultural Student Services

- Oversee the development of the African and African American mentorship program, recruitment and retention, and cultural celebration
- Mentored Stormey Nielsen – current graduate student in social work, University of Utah
- Mentored Madison Hanks - current Ph.D student in Counseling Psychology, Auburn University
- Mentored Abdul Kalumbi - Interned with U.S. Senator Orrin Hatch
- Awarded $10,000 for 2017-18 academic year
- Awarded $50,000 for 2018-19 academic year

PROFESSIONAL MEMBERSHIPS

American Research Education Association (AERA)
Society for Advancement of Chicanos and Native Americans (SACNAS)
Florida-Georgia Louis Stokes Alliance for Minority Participation (FGLSAMP)
African American Student Association (AASA)
Society for Ethics Across the Curriculum (SEAC)
American Association of Colleges & Universities (AAC&U)

MEDIA

2018 Mathematics Education and Leadership News, Volume 8, Issue No. 1 https://teal.usu.edu/graduate/math/newsletters
2018 The UVU Review: Commemoration to MLK Calls Students to Action https://www.uvureview.com/front-page/commemoration-mlk-calls-students-action/
2017 The UVU Review: Black Student Union Strives for University Support https://www.uvureview.com/recent/news/black-student-union-strives-for-university-support/