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Understanding Barriers to STEM: Teachers' Insights on African American Underrepresentation

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ABSTRACT

This study focuses on the development of a measurement instrument to identify Middle and High School mathematics and science teachers' beliefs about the main factors of underrepresentation of African American students in STEM (Science, Technology, Engineering, and Mathematics) fields. The research method using the stages of instrument development were (1) test design which involved construction of initial item pool by conducting extensive review of literature and coding of participating teachers personal statements (2) determination of validity which involved expert review process to confirm construct and face validity of items, (3) pilot testing which involved collecting data from a second set of participants, (4) determination of reliability which involves conducting a reliability analysis based on data collected from pilot testing and (5) determination of factorial structure which involved Exploratory Factor Analysis (EFA) to identify underlying factors in participating teachers' belief structures. First, to obtain trustworthy information, voluntary middle and high school mathematics and science teachers were asked to write personal statements where they explain their main reasons for choosing teaching as a career. Secondly, qualitative data obtained from participating teachers' personal statements were coded. Coding was applied to identify and to group the phrases or sentences that convey the same or similar reasons. Then results from an extensive literature review on this topic were blended in teachers' common expressions which were determined because of coding procedure. Then 8 content experts assessed content validity and face validity. Finally, the survey was piloted to African American middle and high school mathematics and science teachers. Fifty-three (53) surveys were completed and received back from teachers. Then, exploratory factor analysis was conducted to identify any underlying factors in the scale. Reliability analyses were also conducted for both the entire survey and for each of the factors. Results of the study suggested four underlying components: (1) Access and Resources, (2) Role Models and Representation, (3) Bias and Discrimination, (4) Curriculum and Pedagogy.

KEYWORDS

Instrument development; teachers' beliefs; STEM; African American Students.

INTRODUCTION

The underrepresentation of African American students in STEM (Science, Technology, Engineering, and Mathematics) fields is a well-documented issue with profound implications for educational equity. Addressing the underlying causes of the underrepresentation is crucial for ensuring diversity and equity in STEM fields. McGee & Robinson (2020) discussed the diverse ways of identifying multidisciplinary perspectives to increase African Americans and other minorities in STEM fields. Teachers' perceptions significantly influence students' experiences and opportunities in these fields. This literature review delves into the numerous factors that shape teachers' perceptions and examines how these perceptions impact the participation of African American students in STEM education. The article provides a comprehensive understanding of the multifaceted barriers to African American students' participation in STEM and offers actionable recommendations to address these issues. Historically, African American students have encountered systemic barriers in education, such as segregation, inadequate resources, and lower expectations from educators (Oakes, 1990). These historical inequities have contributed to enduring gaps in academic achievement and participation in advanced coursework, including STEM subjects. This study focuses on examining the insights leading to the underrepresentation of African Americans in STEM education.

As noted by Long III and Mejia (2016), despite the societal and educational benefits of diversity, STEM education is dominated by persons whose background is White, male, English speaking, and middle class (National Academy of Engineering and National Research Council, 2009) with minimal representation of other demographic groups. This study examines the deeply entrenched institutional barriers that contribute to the underrepresentation of African Americans in STEM education. In doing so, we believe that a new conversation about diversity and inclusion in STEM education needs to begin; a conversation that examines and attempts to start breaking policies and actions that pose institutional barriers for underrepresented minority students in all aspects of STEM fields.

Objectives and research questions

The objective of this study is to identify the factors that teachers believe play crucial roles in this underrepresentation. Specifically, two research questions are examined in the study:

- What are the key dimensions of mathematics and science teachers’ perceptions that explain the underlying reasons for the underrepresentation of African American students in STEM (Science, Technology, Engineering, and Mathematics) fields?
- What factors contribute to the underrepresentation of African Americans in STEM education?

THEORETICAL FRAMEWORK

This study is based on three significant theories. In the forefront is the Critical Race Theory (CRT). This theory helps in the understanding of the structural and systemic barriers that contribute to the underrepresentation of African Americans in STEM. It introduces the role of such concepts as institutional racism, microaggressions, and the impact of historical inequities. In this study CRT may be applied to help in the understanding of the role of education systems in either perpetuating or challenging racial inequities in STEM education.

Second, the Social Cognitive Career Theory (SCCT) is significant in this study. It helps in explaining the role of self-efficacy, outcome expectations, and personal goals in career development. In this study, SCCT helps in highlighting the importance of contextual factors, such as the availability of role models and access to resources for the African American students. It helps in explaining the decision-making process of African American students regarding STEM careers, considering the influence of teachers as significant figures in shaping these decisions.

Lastly, the Cultural Capital Theory (CCT) explores how Pierre Bourdieu's concept of cultural capital can explain disparities in educational outcomes. Its focus is on the differential access to cultural capital that African American students might experience, particularly in STEM fields. It is helpful in analyzing how teachers perceive and influence the cultural capital of their African American students, potentially affecting their STEM aspirations and achievements.

These theories were found immensely helpful in explaining the underrepresentation of African Americans in different STEM fields.

LITERATURE REVIEW

The representation of different racial groups in STEM education and the contributing factors has been the focus of several studies. Freeman (2021) observed that the differentiation and motivation to be involved in STEM education is rooted in racial identity. Saw (2018) observed that racial/ethnic disparities in STEM career aspirations are dependent on the rate of interest among the various groups. Consequently, the underrepresentation of African Americans in STEM education at K-12 education and undergraduate studies is due to the limited interest in the same. Neally, K. (2021) and several other studies focused on identifying the root causes of this lack of interest and the consequent under-representation. Best (2016) observed that some of these barriers are based on social and cultural attitudes. Numerous other studies indicate that systemic issues in education, such as disparities in access to quality STEM resources and advanced coursework, disproportionately affect African American students. First, are the deeply entrenched historical factors. Tenenbaum and Ruck (2007) observed that in the United States of America, African Americans have historically faced educational barriers due to the systemic racism and segregation. Brown et al. (2016) referred to these barriers as the pipeline problem where early underrepresentation is carried forward throughout school-life. These barriers have rapidly affected the quality of education offered to these communities and hence limited education in STEM areas. Norman (2013) highlighted how these systemic historical barriers create a process of stigmatization that thrives on a century's old legacy. The goal now should be to identify strategies for moving from this stigmatization to motivation and passion for STEM fields.

Oakes (1990) observed that the historical tracking of students in schools has resulted in underrepresentation of African American students in STEM education. Schools in predominantly African American communities often lack access to experienced STEM teachers and other resources. Kozol (2012) noted that these schools are often underfunded with limited access to STEM-based extracurricular activities like science fairs and robotics clubs. He stated that in public education scorns so many children from African American families. This relationship between SES and STEM participation is however not just limited to African Americans. It was also observed by Sovansophal (2020) in a study done in Cambodia. Secondly, several studies have pointed out the fact that there is a close correlation between students in STEM education and socioeconomic status (SES).

It is significant to note that lower-income students where there is a disproportionate number of African American students have fewer resources for STEM education. Yerdelen, S., Kahraman, N., & Taş, Y. (2016) observed that the different measures of SES can be used to predict the participation and achievement in STEM versus Non-STEM education with African Americans being least engaged in STEM areas. Third, is the lack of institutional support of African Americans to be involved in STEM education. In exploring the factors that influence selection of students in STEM among HBCUs, Gasman et al. (2007), Lancaster & Xu (2017) and Yadav et. al (2020) all noted the lack of including institutional support and mentorship, which influence African American students' decisions to pursue STEM careers. The interest in the STEM courses by average students is reduced largely because extremely limited funds will be provided to allow a greater number of financially strapped students to enroll in summer and remedial classes.

Research suggests that barriers are perpetuated by implicit biases and structural inequities within the education system (Ladson-Billings, 2006). Teachers' perceptions and expectations play a pivotal role in influencing students' academic trajectories. Studies have demonstrated that teachers often harbor lower expectations for African American students, which can adversely affect these students' self-efficacy and interest in STEM subjects (Tenenbaum & Ruck, 2007). This phenomenon, known as the "Pygmalion effect," posits that students tend to perform in line with their teachers' expectations, whether high or low (Rosenthal & Jacobson, 1968).

Implicit biases and stereotypes about African American students' abilities in STEM fields are widespread and can shape teachers' interactions and instructional practices. Several studies have highlighted the fact that a considerable proportion of teachers have lower expectations for African American students. This often leads to a lack of much-needed attention, and which affects the students’ performance and interest in STEM.

Research by Banaji and Greenwald (2013) shows that even well-intentioned teachers may unconsciously hold biases that influence their judgments and decisions. These biases can lead to differential treatment, such as providing less encouragement for African American students to pursue advanced STEM coursework or participate in STEM-related activities (Gershenson et al., 2016).

Cultural relevance has been highlighted as a common factor that limits the interest of STEM education by the African American population. STEM curricula, artifacts and resource materials used in teaching often lack cultural relevance, which can disengage African American students. The development of a culturally relevant pedagogy (CRP) has been proposed as a strategy to address the underrepresentation of African American students in STEM fields. CRP involves teaching practices that acknowledge and value students' cultural backgrounds and experiences (Ladson-Billings, 1995). Teachers who implement CRP are more likely to create inclusive and supportive learning environments that foster the academic success of African American students in STEM.

Professional development and teacher training programs aimed at increasing cultural competence and reducing implicit biases are essential for improving teachers' perceptions of African American students in STEM. Programs that equip teachers with strategies for implementing CRP and addressing their biases have shown promise in enhancing student outcomes (Gay, 2000). Additionally, mentorship and support networks for African American students can help counteract negative perceptions and provide positive role models in STEM fields (Lee, 2002).

The broader school and community contexts also influence teachers' perceptions and students' opportunities in STEM. Schools with diverse teaching staff and strong community partnerships tend to offer more positive environments for African American students (Howard, 2010). Community-based programs and initiatives that promote STEM education and careers can also help bridge the gap and support students' aspirations (Museus, Palmer, Davis, & Maramba, 2011).

Despite numerous studies (Carpio et al., 2017; George et al., 2001; Griffith, 2010; Hurtado et al., 2011; Museus et al., 2011; Ong et al., 2011; Rincón & George-Jackson, 2016; Williams et al., 2014; Xue & Larson, 2015) examining the performance and inclusion of minority students in STEM fields, limited research has focused on identifying teachers' beliefs about the main factors contributing to the underrepresentation of African American students in STEM.

Several studies have also highlighted continued stereotyping as a contributing factor. For instance, in a study by Steele & Aronson (1995), stereotyping was highlighted as a significant factor in reducing the number of African Americans in STEM education. They noted that African American students often face negative stereotypes that can hinder their performance and interest in STEM subjects. This foundational work discusses how stereotype threat can affect the overall academic performance of African American students, particularly in STEM fields. Whittaker and Montgomery (2012) highlighted the significance of cultivating diversity and competency in STEM and removing stereotyping and other virtual barriers that have continued to limit the numbers of African Americans in STEM fields.

Lack of role models has been highlighted as a significant factor. Shin *et al.* (2016) noted that the scarcity of African American professionals in STEM can limit students' ability to envision themselves in similar roles, reducing their motivation to pursue these careers. In many instances, cultural perceptions and family expectations of African American communities may not always align with the pursuit of STEM careers, creating additional barriers. For instance, teachers' biases, whether conscious or unconscious, can impact their expectations and interactions with African American students, affecting students' self-efficacy and academic choices.

Although this is not the central focus of this study, it is important to note that the underrepresentation is also gender sensitive. Faride (2012) and Guy and Boards (2019) noted that there is a greater underrepresentation of African American females than their male counterparts. This was also highlighted by Charleston *et al.* (2014) in a study on the role of race and gender in the academic pursuits of African American women in STEM.

METHODOLOGY

Overview of methodology

This study employed a mixed-methods approach, incorporating both qualitative and quantitative methods to collect and analyze data, aligning with its primary objective of exploring teachers' beliefs and perceptions regarding the underrepresentation of African American students in STEM fields. In the analysis of qualitative data, the process involved transcribing the interviews. There was also data cleaning to check for inconsistencies, outliers, or missing data in quantitative datasets. The data coding involved the creation of a coding scheme to categorize responses. This was based on the major themes and the concepts that emerge from the data.

The quantitative analysis involved the application of descriptive statistics that involved calculating the measures of central tendency like the means, medians, modes, and standard deviations to understand the distribution of responses. The inferential Statistics focused on the use of chi-square tests, t-tests, and ANOVA to evaluate significant differences in perceptions. The correlation analysis involved the identification of relationships between different variables (e.g., teacher experience and perception of barriers).

In the overall analysis, the first phase involved a comprehensive review of existing literature on teachers' beliefs and perceptions about the underrepresentation of African American students in STEM. The researchers meticulously analyzed the information from previous studies to generate relevant statements that could be incorporated into the measurement instrument.

In the second phase, volunteer African American middle and high school mathematics and science teachers were invited to write personal statements. These statements were intended to capture their perceptions of the factors contributing to the underrepresentation of African American students in STEM fields. To encourage candid and honest responses, the researchers ensured the anonymity of participants by not including any identifying questions. The qualitative data obtained from these personal statements were then systematically coded. This coding process involved identifying and grouping phrases or sentences that conveyed similar reasons or themes, allowing the researchers to categorize and create factors that accurately reflected the teachers' expressed beliefs.

Building on the insights from the qualitative data and the literature review, the researchers developed a 30-item Likert-type survey. This survey was designed to quantitatively measure the identified factors. The content validity and face validity of the survey items were evaluated by a panel of eight content experts, ensuring that the items were both relevant and clearly articulated.

In the final phase, the survey was piloted with African American middle and high school mathematics and science teachers. A total of fifty-three (53) surveys were completed and returned. The collected data were subjected to exploratory factor analysis (EFA) to identify any underlying factors within the scale. Additionally, reliability analyses were conducted for the entire survey as well as for each individual factor, ensuring the internal consistency and reliability of the instrument.

Participants

This study involved two distinct groups of participants, both currently practicing middle and high school African American mathematics and science teachers who were teaching during the 2022-2023 academic year in Florida public schools.

The first group of participants was requested to write several paragraphs-long personal statements clearly expressing the factors they believe contribute to the underrepresentation of African American students in STEM fields. A total of twenty-four (24) teachers participated in this phase, sharing their insights and experiences through their written statements.

The second group of participants participated in a pilot study, where they were asked to complete a validated survey instrument designed to measure their beliefs about the factors contributing to the underrepresentation of African American students in STEM. Fifty-three (53) teachers completed and returned the survey instrument during this phase, providing valuable data for the study.

Construction and Application of the Instrument

The initial item pool was constructed based on (a) extensive literature review, and (b) participated teachers' personal statements. Throughout the period of draft item preparation, the researchers followed three ways:

First, an extensive review of existing literature about the reasons for underrepresentation of African American students in STEM fields was conducted. The researchers analyzed all the information provided by previous research and generated statements that could be used in the instrument.

Second, Inductive coding, also called open coding (Strauss & Corbin, 1998), strategy was used to analyze and to categorize the phrases and expressions participants used to explain the main reasons which played a role in underrepresentation of African American students in STEM fields. Specifically, steps listed below were followed in coding:

- A personal statement was read thoroughly, and codes were created based on phrases and expressions used.
- A new personal statement was read, applying the codes created for the first statement and additional new codes were created for unmatched expressions. And necessary changes were made such as splitting an existing code into two, combining two or more codes, or changing the description of a code.
- Procedure from step-2 was repeated until all the data in all statements were coded.
- Finally, all statements were read again considering the final list of codes to make sure that same or similar phrases or expressions at different points in the statements did not end up with different codes.

Third, information from both participating teachers' statements and the extensive literature review were combined and a 30-item Likert type survey form was created. Then 8 content experts assessed content validity and face validity. A Likert type scale structure was preferred to ask respondents to indicate their level of agreement with a declarative statement. Scale items were rated as "(5) strongly agree", "(4) agree", "(3) undecided", "(2) disagree" and "(1) strongly disagree".

Using these steps, the researchers were able to identify the factors contributing to Underrepresentation. These were divided into three categories; namely the educational barriers, the lack of access to quality STEM education, underfunded schools, and limited resources and the socioeconomic challenges which include poverty, lack of mentorship, and inadequate support systems.

RESULTS

Validity Analysis

A comprehensive multi-step validity analysis was conducted in this study, focusing on both Content and Face Validities as critical components of the overall validity of the scale.

Content Validity: Content validity assesses whether the items or statements in an instrument are representative of a larger domain of items. In this study, eight faculty members, serving as content experts, evaluated the content validity. Each item was reviewed and rated on a 3-point scale as "high," "moderate," or "low" to judge its relevance. The Content Validity Ratio (CVR) was then calculated for each item using Lawshe's (1975) formula, where "nh" represents the number of jurors indicating "high" relevance and "N" denotes the total number of jurors. For statistical significance at $p < 0.05$, a minimum CVR value of 0.75 was required based on the ratings from the eight content reviewers.

$$CVR = \frac{n_h - \left[\frac{N}{2}\right]}{\left[\frac{N}{2}\right]}$$

Face Validity: Face validity pertains to the clarity of item design and wording in the instrument. The same group of jurors assessed each item's clarity and wordiness, rating them on a 3-point scale as "good," "fair," or "poor." The Face Validity Ratio (FVR) was calculated, with "nG" indicating the number of jurors rating an item as "good" and "N" representing the total number of jurors. A minimum FVR value of 0.56 was necessary for statistical significance at $p < 0.05$, according to the eight content reviewers.

$$FVR = \frac{n_G - \left[\frac{N}{2}\right]}{\left[\frac{N}{2}\right]}$$

Items were retained in the instrument if their CVR and FVR values met or exceeded the minimum thresholds of 0.75 and 0.56, respectively. Consequently, seven items that did not meet these criteria were removed, resulting in a revised version of the instrument with 23 items.

Reliability Analysis

To assess the reliability of the instrument, Cronbach's Alpha was initially calculated and found to be 0.798, indicating an acceptable level of internal consistency. However, to ensure the reliability of the scale was optimized, further analysis was conducted using the "Cronbach's Alpha if Item Deleted" values. This analysis helps identify any items that might negatively affect overall reliability.

As displayed in Table 1, the "Corrected Item-Total Correlation" values for items #6, #14, and #17 were less than 0.3. This low correlation suggests that these items did not correlate well with the total score and, thus, negatively impacted the reliability of the scale.

Table-1.

Item-Total Statistics

Item #	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
6	-0.052	0.837
14	-0.012	0.855
17	0.117	0.841

Given these findings, it was necessary to remove items #6, #14, and #17 from the scale to improve its reliability. After the removal of these items, the remaining items in the scale were renumbered from 1 to 20. Subsequently, Cronbach's Alpha was recalculated for the revised scale to determine the new level of reliability. The recalculated Cronbach's Alpha for the revised scale was found to be 0.867, indicating a higher level of internal consistency and improved reliability.

Exploratory Factor Analysis

This section reveals the results about identifying underlying factors or main dimensions of mathematics and science teachers' perceptions about the reasons for underrepresentation of African American students in STEM fields.

Considering the research question, the construct of the instrument was evaluated to establish structural aspects of reliability evidence. Reliability of the scale was found to be high regarding the value of Cronbach's Alpha coefficient which is 0.867. The underlying assumption in this study was that teachers' beliefs included multiple dimensions; Exploratory Factor Analysis (EFA) was performed until a defensible model for this measure was reached. Therefore, a total of 20 continuous factor indicators (individual items in the scale) were referred to as the observed factor indicators in the model (Table 2). Initially, KMO (Kaiser-Meyer-Olkin) and BTS (Bartlett's Test of Sphericity) tests were applied for the examination of factorability of the instrument. KMO value (0.83715) for measure of sampling adequacy showed acceptable sample size.

table 2. (see appendix)

Principal Component Analysis (PCA) was used as an extraction method. Researchers then identified four underlying components (factors) which had eigenvalues greater than 1.00: (1) Access and Resources, (2) Role Models and Representation, (3) Bias and Discrimination, (4) Curriculum and Pedagogy. Table 2 above shows the distribution of items among four underlying components. These items are:

- (1, 5, 8, 10, 16) are indicators of "Access and Resources".
- (2, 9, 11, 19) are indicators of "Role Models and Representation".
- (3, 12, 14, 15, 17) are indicators of "Bias and Discrimination".
- (4, 7, 13, 18, 20) are indicators of "Curriculum and Pedagogy."

In addition, researchers also developed operational definitions for each component, as outlined in Table 3 (see appendix) to ensure that each component is clearly understood and to provide clarity on what each component entails and how it will be assessed within the context of the study.

Reliability of Factors (Subscales)

In the second phase of the Exploratory Factor Analysis (EFA), reliability of each subscale or each factor was computed. Table-4 below represents the reliability coefficients for the factors (subscales).

Table-4.

Reliability of factors.

Factors	Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
Access and Resources	0.826	0.830	5
Role Models and Representation	0.831	0.835	4
Bias and Discrimination	0.839	0.846	6
Curriculum and Pedagogy	0.820	0.823	5

Each subscale demonstrated acceptable levels of reliability, as indicated by the Cronbach's Alpha values, which all exceed the commonly accepted threshold of 0.70. The Cronbach's Alpha values based on standardized items further confirm the consistency of these subscales. The number of items included in each factor is also listed, reflecting the scope of each subscale.

DISCUSSION AND CONCLUSION

The findings of this study shed light on the complex and multifaceted nature of the underrepresentation of African American students in STEM fields. As noted by Stipanovic & Woo, (2017), promoting racial and ethnic minority students' interest in science, technology, engineering, and mathematics (STEM) careers is of best interest to any organization. It should remain a primary goal for any organization's workforce in its efforts to harvest the benefits of a diverse workforce. There is however scant literature about what influences African American high school students' interest in and choice to pursue STEM careers. There is however a need to identify the knowledge needed to advance the case of STEM education among African Americans. Such information would help educators develop programs to meet the demand for STEM graduates. By developing a measurement instrument that captures the beliefs and perceptions of middle and high school mathematics and science teachers, we have identified key factors that contribute to this persistent issue. The study's results suggest four primary components influencing these perceptions: Access and Resources, Role Models and Representation, Bias and Discrimination, and Curriculum and Pedagogy.

The data indicates that limited access to high-quality STEM education and resources significantly impacts African American students' ability to engage with STEM subjects. This includes disparities in school funding, availability of technology, and extracurricular STEM programs, which are essential for fostering interest and competence in STEM fields.

The lack of African American role models in STEM fields is another critical factor. The presence of relatable role models can inspire and motivate students, helping them envision themselves in similar careers. The absence of such figures can lead to a lack of aspiration and confidence among African American students regarding their potential in STEM. The findings in this study are aligned to the work of Chelberg & Bosman (2019) which highlighted the significance of faculty mentoring in increasing recruitment and retention of African American students in STEM education.

Implicit biases and stereotypes held by educators and the broader educational system can adversely affect African American students' experiences and outcomes in STEM education. Teachers' lower expectations and differential treatment can undermine students' self-efficacy and interest in pursuing STEM subjects, perpetuating the cycle of underrepresentation.

The study also highlights the importance of culturally relevant pedagogy (CRP). Incorporating students' cultural backgrounds and experiences into the STEM curriculum can create a more inclusive and supportive learning environment. Educators who employ CRP are better equipped to engage African American students and address their unique educational needs. White. (2018)

highlighted the need for CRP training to break down the lack of understanding of the cultural barriers hindering inclusion of minorities in STEM education.

The findings of the study underscore the necessity of professional development and training programs for teachers to increase cultural competence and mitigate implicit biases. Such programs can equip educators with the tools needed to implement CRP and support African American students effectively. Additionally, mentorship and support networks play a crucial role in providing positive reinforcement and guidance for these students.

The underrepresentation of African American students in STEM fields is a multifaceted issue that requires a comprehensive approach to address effectively. This study has identified key factors through the lens of middle and high school mathematics and science teachers, providing valuable insights into the barriers that need to be overcome. By focusing on improving access to resources, increasing the presence of role models, reducing biases, and implementing culturally relevant pedagogies, educators and policymakers can make significant strides toward closing the STEM achievement gap. This has recently been noted by May (2023) in a doctoral dissertation.

There are also many invisible barriers that challenge the inclusion of African Americans in different fields of STEM education. Simmons & Lord (2019) proposed that there is a need for exploration of development of successful programs to dismantle the visible and invisible barriers. Future research should continue to explore these dimensions and develop targeted interventions to support African American students in STEM. Ensuring educational equity and diversity in STEM fields is not only a matter of social justice but also essential for fostering innovation and competitiveness in a global economy.

Lastly, there is a call to action in which we urge policymakers, educators, and communities to work together to address these barriers and promote diversity in STEM by actively and intentionally developing procedures to attract more African American students to STEM fields from the preliminary stages of education. As noted by Packard and Fortenberry (2016), continued mentorship and role modeling will go a long way in increasing the minorities in STEM education.

Limitations

There are several limitations associated with this study. First is the limited sample size. A total of twenty-four (24) teachers participated in the first phase of the study. They shared their insights and experiences through their written statements. In the second phase where participants were required to complete a validated survey instrument designed to measure their beliefs about the factors contributing to the underrepresentation of African American students in STEM, a total of fifty-three (53) teachers completed and returned the survey instrument during this phase. Although this can be considered a representative sample, it is small considering the substantial number in the demographic population under study. This may affect the generalizability of the findings to a broader population. The findings have however been validated to be acceptable in the required context. From the analysis, it is noted that the size does not limit the statistical power of the study.

Secondly, the teachers selected for the study might not represent the diversity of all educators. The sample only includes teachers from the selected schools and districts and the insights may not reflect the experiences and perspectives of teachers in different contexts. Similarly, although the insights are based on the selected teachers' perceptions, the personal beliefs, experiences, and biases depending on their backgrounds might influence their views on African American underrepresentation in STEM, potentially skewing the findings.

Third is the limitation of the focus of the study itself. The study is focused on African American Underrepresentation. While this is crucial, it might ignore other underrepresented groups in STEM fields, such as Hispanic or Native American students. Additionally, it might not capture intersectional issues, such as gender or socioeconomic status, which could influence underrepresentation.

Lastly are the rapid changes taking place in education, particularly with technological improvement. Educational practices, policies, and societal attitudes toward STEM and diversity can change quickly. The study's findings might become outdated if there are significant shifts in these areas after the data collection.

Recommendations

This study provides invaluable information about the underrepresentation of African Americans in STEM education. These findings may also apply to the underrepresentation of the same demographic segment in other fields particularly sciences and mathematics. Acknowledging the limitations highlighted above is critical for understanding the study's scope and applicability. Future studies might address these limitations by expanding the sample size, including multiple perspectives, or considering changes with time to provide a more comprehensive understanding of the barriers to African American representation in STEM fields.

It is important in any education setting to address stereotypes and biases by actively working to challenge and dismantle stereotypes that suggest STEM is not for African Americans or that it is only for certain types of students. This will be helpful in the promotion of an inclusive school culture where diversity is valued, and every student feels capable of succeeding in STEM.

The findings from this study can be applied in developing a culturally relevant curriculum and Pedagogy that reflect the cultural backgrounds and experiences of African American students. The significance of a culturally relevant curriculum was highlighted by Olayemi, M., & Deboer (2021) in their study based on enacting culturally relevant pedagogy for underrepresented minorities in STEM classrooms.

These findings can help make STEM subjects more relatable and engaging long after graduation. It can involve the incorporation of examples, case studies, and historical contributions of African Americans in STEM to highlight role models and show the significance of diversity in these fields. Martin and Fisher-Ari (2021) noted the significance of this for the future generations in a study based on perceptions of high school students. They stated that "*If We Don't Have Diversity, There's No Future to See*."

The findings can also be helpful in the professional development of teachers. This would encourage teachers to develop skills to effectively mentor and support African American students in STEM subjects. The findings are also helpful in the creation of educational reforms that help to improve access to quality STEM education, funding, and resources. The significance of the building of mentorship and support programs that include initiatives to provide guidance and support to African American students to be more engaged in STEM fields.

Lastly, it is noted that the introduction of STEM concepts and activities early in students' education sparks interest and builds confidence. Creating after-school programs, summer camps, or clubs focused on STEM that specifically target African American students and provide hands-on learning opportunities.

In conclusion, these recommendations and the entire study aim to create an educational environment where African American students can thrive in STEM disciplines, contributing to a more diverse student body and a more inclusive and innovative workforce.

REFERENCES

Banaji, M. R., & Greenwald, A. G. (2013). *Blindspot: Hidden biases of good people*. Delacorte Press.

Best, B. M. (2016). *Teachers' Perception of African American Middle School Girls' Interest in Mathematics and Science* (Doctoral dissertation, Walden University).

Brown, B. A., Henderson, J. B., Gray, S., Donovan, B., Sullivan, S., Patterson, A., & Waggstaff, W. (2016). From description to explanation: An empirical exploration of the African American pipeline problem in STEM. *Journal of Research in Science Teaching*, *53*(1), 146-177.

Carpi, A., Ronan, D. M., Falconer, H. M., & Lents, N. H. (2017). Cultivating minority scientists: Undergraduate research increases self-efficacy and career ambitions for underrepresented students in STEM. *Journal of Research in Science Teaching, 54*(2), 169-194. https://doi.org/10.1002/tea.21341

Charleston, L. J., Adserias, R. P., Lang, N. M., & Jackson, J. F. (2014). Intersectionality and STEM: The role of race and gender in the academic pursuits of African American women in STEM. *Journal of Progressive Policy & Practice*, *2*(3), 273-293.

Chelberg, K. L., & Bosman, L. B. (2019). The Role of Faculty Mentoring in Improving Retention and Completion Rates for Historically Underrepresented STEM Students. *International Journal of Higher Education*, *8*(2), 39-48.

Farinde, A. A., & Lewis, C. W. (2012). The underrepresentation of African American female students in STEM fields: Implications for classroom teachers. *Online Submission*.

Freeman, K. E., Winston-Proctor, C. E., Gangloff-Bailey, F., & Jones, J. M. (2021). Racial identity-rooted academic motivation of first-year African American students majoring in STEM at an HBCU. *Frontiers in psychology*, *12*, 669407.

Gasman, M., Baez, B., Drezner, N. D., Sedgwick, K. V., Tudico, C., & Schmid, J. M. (2007). Historically Black colleges and universities: Recent trends. *Academe*, *93*(1), 69-77.

Gay, G. (2000). *Culturally responsive teaching: Theory, research, and practice*. Teachers College Press.

George, Y. S., Neale, D. S., Van Horne, V., & Malcom, S. M. (2001). In pursuit of a diverse science, technology, engineering, and mathematics workforce: Recommended research priorities to enhance participation by underrepresented minorities. In *American Association for the Advancement of Science* (pp.1-32).

Gershenson, S., Holt, S. B., & Papageorge, N. W. (2016). Who believes in me? The effect of student-teacher demographic matches on teacher expectations. *Economics of Education Review*, 52, 209-224.

Griffith, A. L. (2010). Persistence of women and minorities in STEM field majors: Is it the school that matters? *Economics of Education Review, 29*(6), 911-922. https://doi.org/10.1016/j.econedurev.2010.06.010

Grossman, J. M., & Porche, M. V. (2014). Perceived gender and racial/ethnic barriers to STEM success. *Urban Education*, *49*(6), 698-727.

Guy, B., & Boards, A. (2019). A seat at the table: Exploring the experiences of underrepresented minority women in STEM graduate programs. *Journal of prevention & intervention in the community*, *47*(4), 354-365.

Howard, T. C. (2010). *Why race and culture matter in schools: Closing the achievement gap in America's classrooms. Teachers College Press*.

Hurtado, S., Eagan, M. K., Tran, M. C., Newman, C. B., Chang, M. J., & Velasco, P. (2011). "We do science here": Underrepresented students' interactions with faculty in different college contexts. *Journal of Social Issues, 67*(3), 553-579. https://doi.org/10.1111/j.1540-4560.2011.01714.x

Kozol, J. (2012). *Savage inequalities: Children in America's schools*. Crown.

Ladson-Billings, G. (1995). Toward a theory of culturally relevant pedagogy. *American Educational Research Journal*, 32(3), 465-491.

Ladson-Billings, G. (2006). From the achievement gap to the education debt: Understanding achievement in US schools. *Educational Researcher*, 35(7), 3-12.

Lancaster, C., & Xu, Y. J. (2017). Challenges and supports for African American STEM student persistence: A case study at a racially diverse four-year institution. *Journal of Negro Education*, *86*(2), 176-189.

Lee, J. M. (2002). *Higher education and African American students: The role of historically Black colleges and universities in addressing the underrepresentation of African Americans in STEM fields*. Johns Hopkins University Press.

Long III, L., & Mejia, J. A. (2016). Conversations about diversity: Institutional barriers for underrepresented engineering students. *Journal of Engineering*, *105*(2), 211.

Martin, A. E., & Fisher-Ari, T. R. (2021). "If We Don't Have Diversity, There's No Future to See": High-school students' perceptions of race and gender representation in STEM. *Science Education*, *105*(6), 1076-1099.

May, J. (2023). *Determining Barriers Black Students Experience Pursuing STEM Degrees: A Qualitative Study* (*Doctoral dissertation, Northcentral University*).

McGee, E. O., & Robinson, W. H. (Eds.). (2020). *Diversifying STEM: Multidisciplinary perspectives on race and gender*. Rutgers University Press.

Museus, S. D., Palmer, R. T., Davis, R. J., & Maramba, D. C. (2011). Racial and Ethnic Minority Students' Success in STEM Education. *ASHE higher education report,* 36(6), 1-140.

Neally, K. (2021). *The Underrepresentation of Minoritized Groups in STEM Education*. Illinois State University.

Norman, O. (2013). African American and other traditionally underrepresented students in school STEM: The historical legacy and strategies for moving from stigmatization to motivation. In *Multicultural Science Education: Preparing teachers for equity and social justice* (pp. 175-192). Dordrecht: Springer Netherlands.

Oakes, J. (1990). *Multiplying inequalities: The effects of race, social class, and tracking on opportunities to gain experience mathematics and science*. RAND Corporation.

Olayemi, M., & Deboer, J. (2021). Enacting culturally relevant pedagogy for underrepresented minorities in STEM classrooms: Challenges and opportunities. *2021 CoNECD*.

Ong, M., Wright, C., Espinosa, L., & Orfield, G. (2011). Inside the double bind: A synthesis of empirical research on undergraduate and graduate women of color in science, technology, engineering, and mathematics. *Harvard Educational Review, 81*(2), 172-208. https://doi.org/10.17763/haer.81.2.t022245n7x4752v2

Packard, B. W. L., & Fortenberry, N. L. (2016). *Successful STEM mentoring initiatives for underrepresented students: A research-based guide for faculty and administrators*. Routledge.

Rincón, B. E., & George-Jackson, C. E. (2016). Examining department climate for women in engineering: The role of STEM intervention programs. *Journal of College Student Development, 57*(6), 742-747. https://doi.org/10.1353/csd.2016.0070

Rosenthal, R., & Jacobson, L. (1968). *Pygmalion in the classroom: Teacher expectation and pupils' intellectual development*. Holt, Rinehart & Winston.

Saw, G., Chang, C. N., & Chan, H. Y. (2018). Cross-sectional and longitudinal disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status. *Educational Researcher*, *47*(8), 525-531.

Shin, J. E. L., Levy, S. R., & London, B. (2016). Effects of role model exposure on STEM and non-STEM student engagement. *Journal of Applied Social Psychology*, *46*(7), 410-427.

Simmons, D. R., & Lord, S. M. (2019). Removing Invisible Barriers and Changing Mindsets to Improve and Diversify Pathways in Engineering. *Advances in Engineering Education*.

Sovansophal, K. (2020). Family socioeconomic status and students' choice of STEM majors: Evidence from higher education of Cambodia. *International Journal of Comparative Education and Development*, *22*(1), 49-65.

Steele, C. M., & Aronson, J. (1995). Stereotype threat and the intellectual test performance of African Americans. *Journal of personality and social psychology*, *69*(5), 797.

Stipanovic, N., & Woo, H. (2017). Understanding African American students' experiences in STEM education: An ecological systems approach. *The Career Development Quarterly*, *65*(3), 192-206.

Tenenbaum, H. R., & Ruck, M. D. (2007). Are teachers' expectations different for racial minority than for European American students? A meta-analysis. *Journal of Educational Psychology*, *99*(2), 253-273.

White, S. (2018). *Secondary School Teacher Perceptions and Role in the Underrepresentation of African American Students in Gifted Education* (Doctoral dissertation, Concordia University (Oregon).

Whittaker, J. A., & Montgomery, B. L. (2012). Cultivating diversity and competency in STEM: Challenges and remedies for removing virtual barriers to constructing diverse higher education communities of success. *Journal of Undergraduate Neuroscience Education*, *11*(1), A44.

Williams, J. C., Phillips, K. W., & Hall, E. V. (2014). *Double jeopardy? Gender bias against women in science*. Hastings College of the Law, Center for Work LIFE Law.

Xue, Y., & Larson, R. C. (2015). STEM crisis or STEM surplus? Yes, and yes. *Monthly Labor Review, 2015*, 1-23. https://doi.org/10.21916/mlr.2015.14

Yadav, A., Seals, C. D., Sullivan, C. M. S., Lachney, M., Clark, Q., Dixon, K. G., & Smith, M. J. (2020). The forgotten scholar: underrepresented minority postdoc experiences in STEM fields. *Educational Studies*, *56*(2), 160-185.

Yerdelen, S., Kahraman, N., & Taş, Y. (2016). Low socioeconomic status students' STEM career interest in relation to gender, grade level, and STEM attitude. *Journal of Turkish Science Education*, *13*(special), 59-74.

APPENDIX

Table-2.

EFA Item Distribution

Item #	Items	Components 1	2	3	4
1	African American students lack access to high-quality STEM education in early grades.	0.793			
2	There are insufficient role models of African American professionals in STEM fields for students to look up to.		0.633		
3	African American students face bias and discrimination in STEM educational settings.			0.692	
4	The STEM curriculum does not incorporate culturally relevant examples and content for African American students.				0.866
5	African American students have limited exposure to STEM career opportunities.	0.654			
6	Teachers and counselors have low expectations for African American students in STEM subjects.			0.780	
7	African American students often lack confidence in their abilities to succeed in STEM subjects.				0.702
8	There is a lack of extracurricular STEM programs available to African American students.	0.911			
9	African American parents may not have the resources to support their children's STEM education.		0.626		
10	School funding disparities negatively impact African American students' STEM education.	0.657			
11	African American students are discouraged by the lack of diversity among STEM teachers.		0.604		
12	There is a stereotype that African American students are not as capable in STEM subjects as their peers.			0.667	
13	African American students are not sufficiently encouraged to take advanced STEM courses.				0.832
14	African American students face a higher incidence of disciplinary actions, which disrupts their STEM learning.			0.843	
15	The STEM learning environment is often unwelcoming or hostile to African American students.			0.922	
16	African American students often lack access to technology and resources needed for STEM learning.	0.712			
17	There is a perception that STEM fields do not value diversity and inclusion.			0.830	
18	African American students may have different learning styles that are not accommodated in STEM teaching methods.				0.604

19	African American students have limited opportunities for mentorship in STEM fields.	0.827	
20	There is a lack of professional development for teachers on how to support African American students in STEM.		0.829

Table 3.

Operational definitions of components and sample items on belief scale.

Components (Factors)	**Operational Definitions**	**Sample Items**
Access and Resources	Giving emphasis to the importance of access and resources.	African American students often lack access to technology and resources needed for STEM learning.
Role Models and Representation	Giving emphasis to value of the role models and representation	There are insufficient role models of African American professionals in STEM fields for students to look up to.
Bias and Discrimination	Giving emphasis to the effect of bias and discrimination.	Teachers and counselors have low expectations for African American students in STEM subjects.
Curriculum and Pedagogy	Giving emphasis to inclusiveness issues and problems in STEM curriculum and instructional practices.	The STEM curriculum does not incorporate culturally relevant examples and content for African American students.