Journal of Social Sciences

Original Research Paper

The Role of Mentoring in STEM Faculty Leadership to Broadening Participation in STEM Faculty and Students

[1]Kula A. Francis and [2]Karyl Askew

[1]College of Liberal Arts and Social Sciences, University of the Virgin Islands, United States
[2]Center for the Advancement of STEM Leadership, University of the Virgin Islands, United States

Article history
Received: 27-06-2022
Revised: 17-08-2022
Accepted: 23-08-2022

Corresponding Author:
Kula A. Francis
College of Liberal Arts and Social Sciences, University of the Virgin Islands, United States
Email: kfranci@uvi.edu

Abstract: Mentoring in faculty development is seen as a catalyst to broaden the participation of underrepresented groups in Science, Technology, Engineering, and Mathematics (STEM) leadership. STEM faculty leaders are organizational influencers with or without formal authority or appointments. Within the fields of STEM, mentoring is often construed as more than senior faculty mentoring junior faculty. This study explores the perspectives of 13 professors and chairs at Historically Black Colleges and Universities (HBCUs) on faculty mentoring based on semi-structured interviews conducted by the Center for the Advancement of STEM Leadership (CASL). The main questions addressed in this study are: What, if any, mentoring styles or strategies do STEM faculty leaders acknowledge and employ? What specific leadership styles are associated with mentoring in HBCUs for STEM faculty who acknowledge mentoring as an aspect of their leadership? The findings of this study suggest that STEM faculty leaders who adopt transformational, servant leadership, and intellectual styles find value in mentoring.

Keywords: Faculty Leadership, Mentoring, STEM, HBCU, Higher Education

Introduction

Faculty development plays an important part in the success of Science, Technology, Engineering, and Mathematics (STEM) education. Historically, faculty have a direct role in student learning and its effectiveness. STEM faculty are also viewed as being responsible for ensuring that graduates are professionally prepared to satisfy the growing demands of a STEM workforce. Huderson and Huderson (2019) argued that a prepared STEM workforce is closely linked to societal advancement. Additionally, STEM faculty play a significant role in student retention and recruitment. Bowling (2005) acknowledged that STEM faculty can offer impactful disciplinary training, mentorship, and coaching due to their academic proximity and opportunities for building pedagogical relationships. Based on their expertise, STEM faculty are “pivotal in the successful implementation of STEM reform and educational enhancement initiatives” (Gandhi-Lee *et al*., 2017). Professionally, STEM faculty are tasked to furnish innovative pedagogical/instructional practices, maintain teaching achievements, adhere to a sustainable research trajectory, appropriate grant funding, and assume various leadership roles. As if this wasn’t enough, faculty are encumbered with the duty to promote their discipline and generate landmark research initiatives.

Thus, Younas *et al*. (2020) described faculty development as “the art of building bricks one by one over a long period into the construction that makes the faculty or the pillars". Faculty must be provided with the skills needed to achieve within their chosen STEM field throughout their professional career. Faculty development can also be characterized as a "series of activities that strengthen and extend the existing knowledge, skills, and attitudes of faculty” (Iqbal and AlSheikh, 2018). While faculty development often consists of workshops, training seminars, and programs, consideration must be given to mentoring. Confirmed that mentoring is an invaluable form of faculty development. Mentoring can be defined as the "relational practice in which a more experienced person helps a less-experienced person develop and advance at work" (Yip and Walker, 2022). asserted that mentoring improves the teaching skills of faculty and in turn enriches the learning environment. It can also be seen as an effective way to groom junior faculty for their role and, in particular, their role in advancing the future of STEM education (Puri *et al*., 2012). Mentoring has the potential to increase productivity, retention, and, most notably, the participation of women and persons of color within STEM faculty. Cultivating inclusivity in the culture of STEM

programs has been identified as instrumental in diversifying STEM faculty (Wehrwein, 2018). For this study, we include the diversification of STEM faculty within the domain of broadening participation in STEM. That is, an institutional effort to increase the diversity of people and talent that contribute to, participate in, and benefit from STEM education.

HBCUs are an ideal context in which to examine efforts to broaden participation in STEM. HBCUs have demonstrated remarkable leadership in broadening the participation of underrepresented students who later go on to graduate school and professions in STEM including the professoriate (Boncana *et al*., 2021; Taylor *et al*., 2021). In addition, as the nation's population grows increasingly diverse, the demographics of HBCU faculty continue to shift and diversify NCSES, 2021 (Taylor *et al*., 2021) in press). The faculty at HBCUs is considerably more diverse than the faculty at predominantly white institutions, and non-Black student enrollment has increased considerably to 24% in 2020 compared with 15% in 1976 NCSES, 2021. HBCUs are not alone in facing the challenge to recruit and retain STEM faculty from under-represented groups, especially given the legacy of historic funding inequities. However, the literature suggests that HBCU leadership is strategic and creative in their use of strategies to recruit and retain talented STEM faculty (Clavier and Engerman, 2021; McClintock *et al*., 2021; McGee *et al*., 2021; Okpala *et al*., 2021).

This study will focus on the concept of mentoring from the standpoint of HBCU STEM faculty leaders. HBCU STEM faculty leaders have been characterized as champions and innovators of broadening participation in STEM learning (Hendrickson *et al.*, 2021). In frontline management or department chair positions, STEM faculty leaders have formal institutional authority and/or informal influence (Kezar and Lester, 2014). STEM faculty leaders can be viewed from the forefront as change agents, improving STEM learning through direct involvement (2014). Furthermore, they are integral in conducting high-quality and highly recognized research projects. As such, STEM faculty leaders are identified by their colleagues as having both social and cultural influence in their institutions, being well-known and respected in the academic community, and serving as role models to aspire to (Frady, 2019).

Even though mentoring is a desired skill for STEM faculty leaders, there is limited research on the impact of leadership styles on mentoring ability. Thus, this study examines the following question: What, if any, mentoring styles or strategies do STEM faculty leaders acknowledge and employ? What specific leadership styles are associated with mentoring in HBCUs for STEM faculty who acknowledge mentoring as an aspect of their leadership? This writing also offers an understanding of mentoring and leadership experiences of STEM faculty leaders who participated in a study conducted by the Center for the Advancement of STEM Leadership (CASL).

Literature on Leadership and Mentoring

In the current body of literature, there are conceptual distinctions between leadership and mentoring. However, several scholars endorse an overlap between both the notions and activities of leadership and mentoring (Sosik and Godshalk, 2000; Sarpong, 2022; Shek and Lin, 2015). Shek and Lin (2015) argued that both leaders and mentors see the need for developing others. They also noted that many models of leadership identify mentoring as an essential task for leaders (Shek and Lin, 2015). Mentoring by faculty leaders is a demonstration of interest and personal concern for those they serve (Sarpong, 2022). As such, mentoring by faculty leadership can be defined as the "formal and informal social construction of professional performance expectations developed through purposeful interactions between aspiring and practicing principals in the context of authentic practice" (Browne-Ferrigno and Muth, 2006, p. 276).

Mentoring requires faculty leaders' willingness to build a close inter-relationship between themselves and their peers or colleagues. Leaders as mentors strive to "shape values, act as an example and define meanings for protégés" (Sosik and Godshalk, 2000, p. 294). In this dyadic relationship (mentor-protégé or leader-follower), faculty leaders offer guidance, encouragement, direction, and feedback. In addition, mentoring also provides an opportunity for two-way development between faculty leaders and their protégés (Chan, 2014). The mentoring relationship provides opportunities to share knowledge and differing perspectives. Additionally, mentoring affords faculty leaders openings to expand their institutional influence.

The following sections offer a discussion on the typology of faculty peer mentoring and faculty leadership styles that have been closely linked to mentoring.

Typology of Faculty Peer Mentoring

Regardless of the purpose, mentoring has common behaviors, activities, and initiatives within higher education. Mentoring is endorsed and advocated within all areas and levels of university life. Sand and colleagues (1991) suggested that beginning students, faculty, and even administrators should seek the aid and support of mentors. Specifically, they noted that faculty mentoring of peers is distinct, complex, multidimensional, and organized within four categories: (a) Collegial friendship mentoring, characterized by informal, mutually supportive interactions (Hackmann and Malin, 2020): (b) Career-guided mentorship, characterized by support and guidance in career development: (c) Information-driven mentoring, characterized by the availability and utilization of knowledge: And (d) intellectually motivated

mentoring, characterized by collaborations in teaching, research, grant writing, and publication.

In addition to these four categories, there are various styles and approaches to mentoring. The following three faculty mentoring styles are often used in university settings: (a) One-on-one mentoring achieved through counseling sessions, leisure activities, and the provision of academic support (Hur *et al*., 2018): (b) Team mentoring, which occurs when a team of mentors delivers support to mentees (Shamim, 2013): And (c) program mentoring, which involves a more structured atmosphere of support and guidance that includes establishing formal goals and outcomes.

Well-managed mentoring programs can foster a university culture that promotes and rewards quality learning and innovative research (Buck, 2004). Buck (2004) argued that mentoring within universities' academic jurisdiction or the learning process provides opportunities to promote university principles, create real change, and advance collaboration. While framing the construct of mentoring, Buck (2004) also maintained that mentoring is an essential act of leadership. While the inclusion of leadership can imply a hierarchical element to mentoring (from senior to junior faculty), leaders can emphasize care and collaboration in the interaction (Buck, 2004).

Faculty Leadership Styles

Researchers have started to make connections between leadership styles and mentoring by applying the same descriptors used for effective leadership to conceptualize and frame effective mentoring (Godshalk and Sosik, 2007; Sims *et al*., 2021). As there are many leadership styles, it is important to decide which leadership style is effective for advancing quality university mentoring (Amah, 2017). The following leadership styles are commonly identified as related to mentoring: intellectual leadership (Oleksiyenko and Ruan, 2019), transformational leadership (Sahu and Pathardikar, 2015), transactional leadership (Pieterse *et al*., 2010), servant leadership (Parris and Peachey, 2013), and passive avoidant leadership (Sosik and Godshalk, 2000). Each is defined below. Common descriptors of leadership behaviors are provided:

- Intellectual leadership is defined as the "individual and collegial capacity to create powerful ideas that spur scientific, social, technological and institutional revolutions" (Oleksiyenko and Ruan, 2019, p.3). Liderliği (2015) established that experienced faculty, as intellectual leaders, have the responsibility of ensuring the production of scientific knowledge, the expansion of their disciplines, and importantly mentoring less experienced faculty. Baris (2020) found six descriptive behaviors of intellectual leaders serving as mentors: (a) Forming research teams: (b) Financing scholarships/fellowships: (c) Co-authoring with mentee(s): (d) Providing feedback on teaching and learning practices: (e) Creating co-advisory opportunities, and (f) developing networks that connect senior and junior faculty
- Transformational leadership is an intrinsic motivational leadership style that builds relationships with individuals and colleagues through the morality of aspiration (Sahu and Pathardikar, 2015). Eight descriptors of transformational leaders serving as mentors are: (a) Vision building: (b) Standard bearing: (c) Integrating: (d) Fostering trust: (e) Providing individualized consideration: (f) Cultivating the independent mindset and the intellectual growth of mentee(s): And (g) providing inspiration and motivation for change (Bottomley *et al*., 2014; Sosik and Godshalk, 2000)
- Transactional leadership is a style of leadership aimed at fostering strong relational exchanges. Transactional leadership requires the delivery of clear expectations to followers (Pieterse *et al*., 2010, p. 610). As mentors, transactional leaders set goals and reward mentees for their accomplishments. The following are five descriptive behaviors of transactional leaders serving as mentors: (a) Negotiating: (b) Seeking agreement: (c) Performing structured relational exchanges: (d) Communicating: And (e) offering rewards
- Servant leadership is a style of leadership that recognizes the role of an organization in developing professionals "who can build a better tomorrow" (Parris and Peachey, 2013, p. 378). Servant leadership prioritizes meeting the needs of mentees and advocating mentees' involvement within the "larger community in which the organization is embedded" (Wu *et al*., 2021, p. 1). Thirteen descriptors of behaviors of these leaders serving as mentors are: (a) Maintaining humility: (b) Demonstrating relational power; (c) valuing autonomy: (d) Listening: (e) Empathizing: (f) Healing: (g) Exhibiting awareness: (h) Persuading: (i) Conceptualizing: (j) Showing foresight: (k) Prioritizing stewardship: (l) Committing to the growth of people: And (m) building community (Barbuto Jr and Wheeler, 2006)
- Passive avoidant leadership is described as the endeavor of leaders "to maintain the status quo through delay, absence, and indifference" (Sosik and Godshalk, 2000, p. 372). Passive avoidant leadership can be perceived as inactive, unreceptive, neglectful, and negligent (Zacher *et al*., 2011). Thirteen descriptive behaviors of passive avoidant leaders serving as mentors include: (a) Avoidance of direct supervising: (b) Avoidance of mentoring: (c) Limiting the appearance of leadership: (d) Avoidance of decision-making; (e) lack of monitoring: (f) Delaying actions: (g) Demonstrating willingness to ignore and abdicate responsibilities: (h) Being unresponsive to mentees' problems: (i) Lack of monitoring: (j) Being inattentive: (k) Showing

indifference: (l) Acting uncaring of mentees' needs; and (m) Limiting involvement in institutional matters (Sischka *et al*., 2020)

Materials and Methods

Study Design

To examine the mentoring and leadership experiences of STEM faculty leaders, this exploratory qualitative study used thematic analysis of interview transcripts to identify patterns and themes (Chung *et al*., 2020). Through the utilization of Atlas. Ti software and the descriptors identified from five identified leadership styles pulled from the literature (intellectual leadership, transformational leadership, transactional leadership, servant leadership, and passive avoidant leadership), open coding permitted the exploration of data. Themes were then identified based on the depth of representative quotes and frequency of code appearance.

AtlasTi software allowed us to search for certain words, quotes, and concepts within the data. It also gave us the opportunity to code, categorize, and manage the findings.

Data Collection

Data for this study were collected by the Center for the Advancement of STEM Leadership (CASL). CASL is funded by the National Science Foundation's HBCU Undergraduate Program (HBCU-UP) and is a collaboration among the University of the Virgin Islands, Fielding Graduate University, North Carolina A&T State University, and the Association of American Colleges and Universities. The overall mission of CASL is to examine the leadership styles and strategies that have been associated with the remarkable record of HBCUs in broadening participation in STEM. As such, the CASL research team recruited HBCU leaders to participate in semi-structured interviews centered on three areas: Leadership styles for broadening participation in STEM, leadership successes and challenges in STEM, and institutional STEM climate and policies.

CASL requested that a senior-level administrator, such as the president or provost, at each institution serve as a point of contact. Given their senior administrative role and knowledge of the institutional context, points of contact were asked to nominate five individuals who could speak to the legacy of leadership in broadening participation in STEM at their institution. Nominations included academic administrative leaders such as deans and faculty leaders. CASL defined faculty leaders as individuals perceived by peers (or others at the institution) as worthy of paying attention to or following because of their wisdom and experience. The interviews were completed by single interviewers from the CASL Research Team. Each interview session lasted between 60 to 90 min and was conducted virtually through Zoom videoconferencing governed by IRB-approved protocols. The sessions were video recorded, and the responses were later transcribed.

Study Sample

The data for this study came from CASL's 2020 HBCU Leaders Dataset. This dataset contained 38 interviews of leaders (including presidents, provosts, deans, chairs, and professors) employed at 13 HCBUs at the time of data collection. The sample for this study consisted of 13 participant faculty leaders holding the position of professors (n = 8) and chairs (n = 5). As displayed in Table 1, 92 of the participants had PhDs; one participant had a Doctor of Arts (DA). Sixty-two percent of the participants were women. Sixty-nine percent of the participants worked in STEM schools at small public and private institutions with enrollments of fewer than 2500 students (Table 1). To ensure clarity, confidentiality, and anonymity, chairs, and professors were identified by numbering. Chairs were given numbers one through five. Professors were given numbers one through eight.

Table 1: HBCU faculty leader: Individual and institutional characteristics

Leader demographics				Institutional characteristics	
Pseudonym	Gender	Degree level [a]	Disciplinary area	School size [b]	School type
Professor #1	Female	Ph.D.	Biology	Medium	Public
Professor #2	Male	D.A.	Chemistry	Small	Private
Professor #3	Male	Ph.D.	Mathematics	Small	Private
Professor #4	Female	Ph.D.	Physics	Large	Public
Professor #5	Female	Ph.D.	Zoology	Small	Public
Professor #6	Female	Ph.D.	Physics	Small	Private
Professor #7	Male	Ph.D.	Medicine	Small	Private
Professor #8	Female	Ph.D.	Anatomy and Neurobiology	Small	Public
Chair #1	Male	Ph.D.	Chemistry	Small	Private
Chair #2	Female	Ph.D.	Biology	Small	Private
Chair #3	Female	Ph.D.	Computer science	Large	Public
Chair #4	Female	Ph.D.	Biology	Large	Public
Chair #5	Male	Ph.D.	Mathematics	Small	Public

[a]Degree level was self-reported by the respondents
[b]CASL classified institutions as small (<2500 students), medium (2501-5000 students), and large (>5000 students)

Results

Several relevant themes within mentoring and leadership styles were discovered. Themes within mentoring are presented first, followed by themes within leadership styles. Based on leadership styles presented within the literature review, the presence of intellectual leadership, transformational leadership, and servant leadership were found within the thematic analysis. Additionally, the presence of two additional leadership styles categorized as systematic leadership and reluctant leadership was also uncovered.

Mentoring

Through the accounts of chairs #2 (female from a small, private HBCU), #3 (female from a large, public HBCU), and #5 (male from a small, public HBCU), as well as professors #3 (male from a small, private HBCU) and #8 (female from a small, public HBCU), mentoring of faculty within STEM higher education can be considered from various viewpoints. Chair #2 stated that accomplishments in STEM education involve "pulling in…that funding to keep us going and providing opportunities, not only for my junior faculty but also for my students." Chair #2 also observed that young professionals entering STEM higher education must be "guided to understand the pitfalls and things that they may encounter." Chair #2 further noted the need for mentors to support their mentees and be willing to stay in contact with them.

Chair #3 provided a key finding related to the importance of mentoring in broadening participation in STEM higher education. Chair #3 recognized that STEM education provides an opportunity to empower women, especially African American women. Chair #3 believed that chairs serving as mentors and coaches can help make STEM programs inclusive of all women of diverse backgrounds. Chair #3 considered broadening participation as part of empowering faculty to see an achievable future within STEM.

Chair #5 was asked, "what do you think are the leadership characteristics that are common amongst HBCU leaders now and in the past that resulted in large numbers of African American STEM majors, graduates, doctoral degree candidates, and those entering into the STEM workforce?" Chair #5 positively responded that STEM culture includes valuing mentoring. Chair #5 believed the mentoring found in STEM education is ingrained in the very fabric of HBCUs' culture of nurturing. Chair #5 also asserted that mentoring is vital to the success of faculty.

In terms of professors' views of mentoring, the comments of Professor #3 underscored a surety that mentoring can be achieved through role modeling. Role modeling is a process of identification and emulation. Professor #3 noted that role modeling is achieved based on mentees' recognition of the mentor's presence within the university and STEM. Professor #3 noted that mentors can become role models through their performance, and academic and organizational achievements. Professor #3 described role modeling as a mentee seeing the mentor make things better for others. Professor #3 also commented that mentees' performance will improve by following the example set by mentors. By setting a good example, mentors can convey a necessary realism and achievability of the required faculty performance to their mentees.

Lastly, Professor #8 expressed the need for senior faculty to mentor younger faculty through collaborative efforts in research. Senior faculty mentoring junior faculty provides mentees with an opportunity to gain from mentors' wealth of experience. Mentoring in research affords junior faculty the necessary guidance on how to properly complete research. Mentoring in research also creates opportunities for junior faculty to develop a research agenda. Professor #8 positively exclaimed, "we need to get the younger faculty who are coming behind us engaged in research."

Leadership Styles

All participating chairs and faculty leaders were asked to describe or self-identify their leadership styles. Based on their descriptions, the following leadership styles were identified and discussed: (a) Intellectual leadership: (b) Transformational leadership: (c) Servant leadership: (d) Systematic leadership: And (e) reluctant leadership.

Intellectual Leadership

Based on the literature review, intellectual leadership was defined as the capacity to direct and guide advancements that are collegial, scientific, and disciplinary. The following themes emerged from the thematic analysis of participating chairs' and professors' transcripts: (a) Openness to innovative approaches: (b) Credentials in the STEM field: (c) Collegiality: And (d) active scholars. Chair #1 noted that intellectual leadership spotlights an openness to innovative approaches within the parameters of achieving set outcomes. Chair #1 also stated, "The leadership skills require having diverse qualities and credentials in the STEM field. Qualities and credentials in STEM fields promote globalization and lead to socio-economic opportunities."

Professors #1 and #8 described the characteristics of intellectual leadership. Professor #1 offered that intellectual leadership requires faculty leaders to develop collegiality to achieve improvements in STEM. Professor #1 stated that they were working together with colleagues to acquire funding to develop a STEM Center. Significantly, Professor #8 remarked that STEM leaders, as intellectual leaders, should be active scholars. Professor #8 stated A leader should have an active research agenda so that other faculty members may also say, "Hey, it's important to make sure that I have an active research agenda!" Whether that research is bench research or more for pedagogy type of research, faculty must be engaged, and the leader needs to be engaged or in close contact with what's going on scientifically in the world.

Transformational Leadership

While a review of the literature provided several descriptors of transformational leadership (e.g., vision builder, standard bearer, integrator, builder, trust), the following themes emerged from the thematic analysis of participants' transcripts: (a) Establishing shared visions: (b) High expectations: (c) Collaboration: (d) Leading by example: And (e) empowerment.

At the very core of transformational leadership is the establishment of shared visions, which Sen and Eren (2012) described as, "reflections of our fundamental beliefs and expressions of our strong desires, aspirations, and dreams to achieve something great" (p. 5). Sen and Eren also identified that a shared vision provides inspiration and motivation to "unite people in a common effort" (p. 5). Chair #4 endorsed those advancements in STEM higher education occurred through shared visions of transformational leaders. Chair #4 also offered a collaborative vision aimed at broadening participation in STEM and STEM mentoring, which is "bringing the right people with the right skills into academics."

In tandem with providing visions, transformational leaders must hold high expectations. High expectations can be described as elevated performance agendas set by leaders. Doody and Doody (2012) asserted that leaders must communicate high expectations. They believed that this motivated their campus community members and partners to strive for "higher ideas and moral values" (p. 1212). Professor #3 suggested that "high expectations are set by exemplary measures." Professor #3 explained that leaders must develop a climate of high expectations for their performance, as well as the people that they work with and serve. Professor #3 stated that "the people will see me doing a job or helping out, will see that high expectations must be set toward that end."

Transformational leadership can be considered collaborative. Transformational leadership is not just about identifying and articulating a vision. Chair #2 offered that transformational leadership requires "visualizing a leader's capacity as being a convener of groups." Chair #2 also highlighted that as a group, leaders work with the people they serve to develop strategies for accomplishing established visions. Chair #2 also commented that transformational leaders, as collaborators, are willing to seek, be, or select a good coach to pull their team together and "know when to pull the reins and know when to loosen the reins." Chair #2 described transformational leadership as having "a lot of trial and error along the way in trying to come up within this model of being able to work with people."

Leading by example is paramount to transformational leadership. Professor #2 explained that leading by example means "never asking someone to do anything that you wouldn't do." Professor #2 also noted that leading by example also requires being open and truthful, which means being able to admit what you don't know and say, "let's check this out, let's research this up." Leading by example means being a role model. Through leading by example, professors offer points of reference for junior faculty performance in STEM education.

Finally, the thematic analysis uncovered the attribute of empowerment as a form of leadership style. Empowerment can be defined as a process whereby leaders strive to instill confidence and nurture self-efficacy, which has been associated with transformational leadership (Kark *et al*., 2003; Krishnan, 2012). Professor #5 added that empowerment requires "letting [mentees] know they can do it, letting them know how to do it, giving them a lot of feedback." Additionally, Chair #3 asserted that empowerment creates feelings of accessibility and inclusivity in STEM for faculty and students. Regarding empowerment, Chair #3 wrote, "I'm not the brightest star in the sky, but I'm a star and you are too!"

Servant Leadership

The interviews by Chair #5 and Professor #8 offered supportive insight into servant leadership in STEM higher education. In STEM higher education, Chair #5 recognized "leadership as a service role where you're providing a service to help people be successful and succeed in their goals." Furthermore, Professor #8 offered, "I believe in doing so others can see what you're doing and follow what you're doing. I love working closely with others, using servant leadership to bring calmness, thoughtfulness, and creative thinking."

Thus**,** Servant leadership for these HBCU leaders is other-directed and geared to servicing the greater needs of others (Clavier and Engerman, 2021). The demonstration of servant leadership qualities by faculty mentors can help mentees realize and achieve their potential (Eva *et al*., 2019). Scott *et al*. (2020) contended that servant leadership can lead to long-lasting and deep changes in the lives of those who have been served.

Systematic Leadership

In exploring the styles of STEM faculty leaders, Professor #1 offered the utilization of systematic leadership style in achieving transformative STEM advancements. The systematic leadership style involves systematic thinking "to identify various factors that affect the performance of the organization's ability to recognize the interdependence between system components" (Salavati *et al*., 2017, p. 249). Professor #1 offered the view that systematic STEM leaders conduct step-by-step planning and commit to understanding the views of all university community members and partners. Professor #7 also added that STEM leaders using a systematic leadership style can skillfully communicate to ensure that all stakeholders are aware of the requirements to achieve outcomes. Finally, Professor #6 shared that leadership styles that promote organization or systematization ensure that activities "run efficiently and smoothly."

Reluctant Leadership

While all the other chairs and faculty leaders attempted to describe their leadership styles in an impactful way, Professor #4 described the existence of reluctant leadership in STEM education. Reluctant leaders have all the characteristics and skill sets to be excellent leaders but choose not to actively take on leadership or administrative positions. Professor #4 asserted that reluctant leaders are "not outwardly seeking" supporters, followers, or mentees. Even though they are deemed "reluctant," these leaders are sought out by junior faculty members for assistance and provision of their expertise. Interestingly, Professor #4 noted that "junior faculty came to me as [a] new pathway to offer my services or provide my services." Even though reluctant, Professor #4 used a participatory leadership style, where she led by example and strived to empower individuals. Professor #4 stated, I allow individuals to work where their skills and talents align so that they are contributors to the entire process. Then, they would be fully acknowledged because of being part of the process of the organization, program, or whatever project that must be done.

Discussion

This study intended to examine the following questions: What, if any, mentoring styles or strategies do STEM faculty leaders acknowledge and employ? What specific leadership styles are associated with mentoring in HBCUs for STEM faculty who acknowledge mentoring as an aspect of their leadership? To respond to these questions, Table 2 presents discoveries of mentoring based on the responses of the respective chairs and professors. Of the 13 respondents whose transcripts were analyzed, only five were explicit about the role of mentoring as a leadership responsibility. These respondents noted the need for faculty leaders to focus on providing collaborative opportunities for mentees/junior faculty. The discoveries listed in Table 2 support the notion that mentoring by faculty leadership can provide opportunities for broadening participation in STEM higher education through acts of faculty leaders endeavoring to empower their mentees.

Findings summarized in Table 2 also spotlight the need for STEM faculty leaders to serve as role models to their mentees, and to expand the representation of STEM faculty in more formal administrative roles. Mentees must be provided with an atmosphere of nurturing and mentoring that is exemplified in HBCU. Brown *et al*. (2009) confirmed that mentoring junior faculty can improve and enrich the development of their research skill and increase their professional success. Finally, Table 2 includes the self-identified leadership styles of participants whose narrative responses demonstrated evidence of mentoring by STEM faculty. The respective participants self-identified their leadership styles as being transformational leadership (Chairs #2 and #3, Professor #3), servant leadership (Chair #5), and intellectual leadership (Professor #8).

Limitations

The findings of this research provided noteworthy implications concerning the significance of STEM faculty leaders as mentors. Nonetheless, there were limitations to the study. While evidence of mentoring was prevalent, the original research protocol focused on leadership styles for broadening participation in STEM, leadership successes and challenges in STEM, and institutional STEM climate and policies, and not on assessing mentoring styles and strategies of faculty. Therefore, we can infer the salience of mentoring to the respondents, but caution is warranted in concluding the prevalence of mentoring. Furthermore, the data used in this study were based on in-depth, interviewer-administered data collection. While the protocols encouraged candor and stated that there were no right or wrong answers, consideration must be given to social desirability bias. Social desirability bias is an error that occurs when participants endeavor to offer a favorable image to researchers (Kim and Kim, 2016). In addition to social desirability bias, we acknowledge the lead author's positionality as an HBCU faculty member and worked to mitigate the possibility of biases in analyses through searching for discrepant evidence and negative cases, as well as co-authorship. Finally, the findings offer insight into the relationship between mentoring and leadership within the HBCU context and for STEM department chairs and faculty members. Future studies will need to establish the transferability of the findings beyond the HBCU context and other leadership roles.

Table 2: Leadership styles associated with STEM faculty mentoring in HBCUs

Participants (gender, school size, school type)	Leadership styles	Mentoring observations
Chair #2 (female; small, private HBCU)	Transformational	(a) Providing funding and opportunities (b) Offering guidance, and (c) building supportive and long-lasting mentor-mentee relationships
Chair #3 (female; large, public HBCU)	Transformational	(a) Broadening participation through empowerment
Chair #5 (male; small, public HBCU)	Servant	(a) Desirability or willingness in mentoring and (b) Mentoring is ingrained in the very fabric of HBCU's nurturing
Professor #3 (male; small, private HBCU)	Transformational	(a) Role modeling
Professor #8 (female; small, public HBCU)	Intellectual	(a) Mentoring in research; (b) sharing of amassed experience; and (c) providing guidance

Conclusion

Scholars have noted the need for broadening the participation of underrepresented groups in leadership roles in Science, Technology, Engineering, and Mathematics (STEM) higher education (Taylor and Wynn, 2019). These concerns derive from the underrepresentation of faculty of color in STEM higher education (Fealing *et al*., 2015). In an attempt to identify beneficial efforts to broaden participation, this research examined the perceptions of STEM faculty leaders on mentoring. The participants who self-identified as transformational leaders with positive and strong views on mentoring were women. They believed that guiding and empowering women would create new avenues for a diverse and inclusive field of STEM leadership. Additionally, participants, who identified mentoring as an important part of their leadership, were generally employed by small STEM programs and colleges. This may have shaped their position on mentoring.

This study suggests that STEM faculty leaders who adopted transformational, servant, and intellectual leadership styles saw vital value in mentoring. Thus, there is a need for further research to explore the associations between mentoring and leadership styles of STEM leaders. Transformational leadership, in particular, provided STEM faculty leaders with suggestions for several motivational behaviors to initiate and maintain developmental relationships with peers and broaden faculty participation in STEM.

Although faculty leaders are often seen as providers of pedagogical innovation and lower-level managerial support, their scholarly and organizational expertise and experience also garner the respect, trust, and confidence of their colleagues (Jacelon *et al*., 2003). As such, STEM faculty leaders must be recognized as important higher education leaders. More importantly, these HBCU faculty leaders can be considered developers and role models for future leaders within STEM. Their capacity as agents of change places them in a key position to develop underrepresented minority and women peers and students in STEM as emerging leaders.

Acknowledgment

This study was supported by the National Science Foundation through the Center for the Advancement of STEM Leadership (CASL) under NSF Grant No. 1818424, 1818425, 1818447, and 1818459. Any opinions, findings, conclusions, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Funding Information

This research was funded by an NSF grant awarded to the Center for the Advancement of STEM Leadership.

Author's Contributions

Kula Francis: Contributions to the conception, design, writing, and editing of the article. She was the primary contributor to the intellectual content, analysis, and interpretation of data and the discernment of findings.

Karyl Askew: Contributed to the conception and development of the manuscript. She supported data management, an internal review for significant intellectual content, and editing of the manuscript.

Ethics

The authors confirm that the content of the article does not violate the confidentiality or reputations of any participants or institutions, nor will any ethical issues arise after the publication of this manuscript.

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