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Applicant qualifications and characteristics in STEM faculty hiring: an analysis of faculty and administrator perspectives

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Abstract

Background The lack of racial diversity in science, technology, engineering, and mathematics (STEM) disciplines is perhaps one of the most challenging issues in the United States higher education system. The issue is not only concerning diverse students, but also diverse faculty members. One important contributing factor is the faculty hiring process. To make progress toward equity in hiring decisions, it is necessary to better understand how applicants are considered and evaluated. In this paper, we describe and present our study based on a survey of current STEM faculty members and administrators who examined applicant qualifications and characteristics in STEM faculty hiring decisions.

Results There are three key findings of the present research. First, we found that faculty members placed different levels of importance on characteristics and qualifications for tenure track hiring and non-tenure track hiring. For example, items related to research were more important when evaluating tenure track applicants, whereas items related to teaching and diversity were more important when evaluating non-tenure track applicants. Second, faculty members' institutional classification, position, and personal identities (e.g., gender, race/ethnicity) had an impact on their evaluation criteria. For instance, we found men considered some diversity-related items more important than women. Third, faculty members rated the importance of qualifications with diversity, equity, and inclusion (DEI)-related constructs significantly lower than qualifications that did not specify DEI-related constructs, and this trend held for both tenure track and non-tenure track faculty hiring.

Conclusions This study was an attempt to address the issue of diversity in STEM faculty hiring at institutions of higher education by examining how applicant characteristics are considered and evaluated in faculty hiring practices. Emphasizing research reputation and postdoctoral reputation while neglecting institutional diversity and equitable and inclusive teaching, research, and service stunt progress toward racial diversity because biases—both implicit and explicit, both positive and negative—still exist. Our results were consistent with research on bias in recruitment, revealing that affinity bias, confirmation bias, and halo bias exist in the faculty hiring process. These biases contribute to inequities in hiring, and need to be addressed before we can reach, sustain, and grow desired levels of diversity.

Keywords Higher education, Faculty hiring, STEM education, Diversity, equity, inclusion

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Introduction

The lack of diversity in science, technology, engineering, and mathematics (STEM) disciplines is perhaps one of the most challenging issues in the U.S. higher education system. Although there has been a more diverse student body as predicted by Wunsch and Chattergy (1991) through significant efforts to increase points of access of racially and ethnically minoritized (REM) students in STEM, demographic changes in faculty have been much slower, with less attention and efforts given to increasing diversity among faculty. In most STEM disciplines in the U.S., REM identities include Black/African American, Hispanic/Latinx, and Indigenous populations including Native American, Alaska Native, and Native Hawaiian/Pacific Islander. The issue in STEM faculty is more than a lack of representation; it is an alarming structural inequity and inequality among U.S. colleges and universities that may lead to serious consequences for students and our society.

As a gateway to the professoriate, the faculty hiring process is a critical component of the system that is responsible for the lack of diversity among STEM faculty. Although many universities state a commitment to diversity and understand the benefits of a diverse academic institution, there are still barriers in hiring faculty members from diverse backgrounds. For example, there are biases—unconscious and conscious, positive and negative—in faculty search processes that disadvantage candidates who are women and/or from REM identities (Roper, 2019; Sackett et al., 1991; Steinpreis et al., 1999; Wapman, et al., 2022; Wenneras & Wold, 1997). Research has shown that women and REM groups are judged more fairly when they are at least 30 percent of the applicant pool (Sackett et al., 1991), but there is an underrepresentation of these groups in applicant pools and short lists for STEM faculty positions (Bilimoria & Buch, 2010). Though many organizations have adopted versions of the "Rooney Rule" (i.e., requiring at least one candidate from a minoritized identity be interviewed for faculty positions), much like the results in the National Football League where that rule originated, there have not been significant improvements in representation among STEM faculty. A study by Johnson et al. (2016) showed there was no chance for a sole woman candidate in an interview pool of four to be hired for academic appointments. On the contrary, the likelihood of hiring a woman or REM increased by 79.14 times and 193.72 times, respectively, when two or more finalists from those identity groups were present in candidate pools. One must question why. Existing faculty make hiring decisions about new faculty, essentially choosing their new colleagues. Hence, it is necessary to understand how faculty search committees go about evaluating applicants, selecting candidates and hiring—how recruitment is conducted and how hiring decisions are made—before we can realize the much-needed change and advancements in faculty hiring practices that result in reduced inequities and improved diversity. In this paper, we examine hiring practices by analyzing applicant characteristics and qualifications reviewed favorably by faculty and administrators involved in searches for entry-level tenure track and non-tenure track STEM faculty.

U.S. faculty hiring processes and institutional classifications

In the U.S., faculty members are generally appointed on one of two tracks: tenure track (or tenure system) or non-tenure track (non-tenure system). Tenure track faculty positions often require the applicant to attend to research, teaching, and service, with strong emphasis on research. Tenure enables faculty to teach, research, and disseminate knowledge with the protection afforded by academic freedom. Non-tenure track faculty positions are often more teaching-focused, with much less emphasis placed on research and service (Ott & Cisneros, 2015; Pearson, 2023). Some institutions hire non-tenure system faculty as researchers with little or no expectations for service or teaching.

Generally, the U.S. faculty hiring process includes the following steps, led to a large extent by search committees. A job announcement is created sent to several outlets to advertise the opening. The committee reviews application materials and narrows the group to a handful of candidates for initial interviews (usually virtual), following which a small number of candidates are invited to a campus interview. Ultimately, the search committee makes a recommendation and the designated administrator (department/program head, dean, etc.) finalizes the decision and extends an offer.

The types of faculty members hired and the requirements for their various roles, whether tenure track or non-tenure track, depend on institutional mission and structure as well as program-specific needs. In the U.S., the Carnegie Classification system is widely used to delineate institutions' basic classifications based on the number and types of degrees awarded and either their research activity, types of programs, or sizes of programs offered. For example, the highly coveted R1 designation refers to institutions with the basic classification "Doctoral Universities—Very High Research Activity". These are "institutions that awarded at least 20 research/scholarship doctoral degrees and had at least $5 million in total research expenditures" during the most recent update year (American Council on Education, 2022). Further classification details include their control structure (e.g., public or private), enrollment profile (e.g., high

undergraduate, majority graduate), and size and setting details (e.g., very small to very large; primarily nonresidential to highly residential).

Barriers to diversity in faculty hiring

Despite the widely reported benefits of having a diverse faculty (Griffin, 2019; Hong & Page, 2004; Page, 2008) and the widespread practice of communicating a commitment to increasing diversity in STEM, many colleges and universities in the U.S. still primarily employ White individuals (Cavanaugh & Green, 2020), and there have not been significant increases in faculty diversity, especially for those from minoritized identities (Sensoy & DiAngelo, 2017). The opportunities, roles, and responsibilities that STEM faculty have in promoting institutional diversity are crucial, especially for those faculty members who serve on hiring committees. Yet, STEM faculty members' hiring practices have not been adequately addressed to date, and many barriers still exist.

One barrier is the lack of diversity among members of hiring committees. According to Arjani et al. (2022), it is necessary to have a faculty search committee that itself is diverse as a first step to create a more diverse group of faculty members. A study by Kazmi et al. (2022) showed search committees that were led by faculty from minoritized identities were more likely to recruit more diverse applicant pools. A challenge in operationalizing these findings is achieving the desired outcomes of more diverse faculty applicant pools without always delegating the invisible, unrecognized labor required by committee service roles to minoritized faculty members. Another challenge is addressing the biases that produce inequities in the hiring process so the diverse pools actually yield more diverse hires.

Imbalances within power structures of hiring committees contribute to reproducing inequity within faculty hiring decisions. For example, Liera and Hernandez (2021) found that faculty inconsistently applied application criteria and throughout the process segregated committee roles through color-evasive racism. More specifically, they explain that abstract liberalism acted as a protector for male senior faculty to use their discretion in assessments of applicant qualifications, which manifested as discrimination against the qualifications of women of color (Liera & Hernandez, 2021).

Another barrier is resistance to faculty hiring-related trainings, which require additional investments of time and effort from committee members. According to Cavanaugh and Green (2020), only 15% of full-time faculty members attended training workshops about faculty hiring. Several points of resistance in trying to establish and support trainings for faculty search committees were identified. For example, there was a notable lack of infrastructure and established workflow, as well as time commitment, to support faculty search committee training. When such trainings and workshops became mandatory for faculty members, there was not even a way to find and contact all of the faculty who were supposed to participate in these trainings. Additionally, individual departments formed their search committees differently and worked on different schedules, so there was not a point where search committee members were completely listed and included (Cavanaugh & Green, 2020).

Besides the formation of and the trainings for faculty hiring committees, research has also examined the various steps of the application process, such as the initial job announcement, the review of applicants' curriculum vitae, the interviews, and the final decisions, to better understand the barriers to hiring diverse faculty members. Results from Sensoy and DiAngelo (2017) indicate that the ways in which faculty decide on candidates is problematic. For example, faculty may hold stereotypes that negatively influence their evaluation of applicants of color throughout the hiring process. During the interview process, people of color not only face the stressors of the application but also need to spend additional efforts navigating an environment with little to no diversity and equity. Moreover, faculty members who are on the search committees may often deflect confrontation of their tendency to choose candidates from dominant groups with biased or color-evasive justifications for their choices, which minimize their own agency and ability to enact change (Sensoy & DiAngelo, 2017).

Perspectives on faculty hiring practices are likely to differ between tenure system and non-tenure system faculty because of financial implications. As Slaughter (2014) found, institutions are increasingly favoring research revenue generation while at the same time cutting back on the labor costs associated with teaching. The consequences of such an operating model have likely led to pronounced differences between tenure system and non-tenure system faculty groups especially regarding the importance of prestigious institutional relationships and teaching qualifications in the evaluation of faculty candidates because tenure track work directly relates to generating research revenue, whereas non-tenure track faculty work does not necessarily. In the context of higher education, these differences in perspectives are created by the class-coded differences that exist between research labor that is very capital-intensive and requires high amounts of spending in terms of new facilities and equipment, compared with teaching labor that is highly labor-intensive and requires recurring spending on compensation for salaries and benefits. The class-coded characteristics of both tenure system and non-tenure system faculty employment could have broad impacts on the terrain of

faculty hiring, because as Bowles and Gintis' (1976) studied, the normative practices within education are highly influenced by class-coded differences within the institution's political economy. Within higher education, these differences translate into differences in normative practices for groups within the institution such as tenure system faculty who lead institutional decision-making and non-tenure system faculty, who are often left out of the process (Ott & Cisneros, 2015).

Perspectives of faculty are likely to also be different when considering candidates whose expertise is DEI-related compared to candidates whose expertise is not in both tenure system and non-tenure system faculty searches because, as White-Lewis (2021) found, job search committees routinely created hiring practices that downplayed the importance of diversity, which holds implications on candidates whose interests are tied closely to DEI. While still generating research revenue, DEI-related research relies on labor-intensive work done by institutional employees and requires institutional buy-in across all levels of employees to be successful. This is an important class-coded difference compared to the capital-intensive non-DEI-related research that is often compartmentalized to a research group whose products can sometimes be commercialized, thus creating even greater revenue for the college or university. The class-coded difference between these research types can lead to normative search committee practices that devalues the contributions of DEI-related research within the holistic transformation of institutions in favor of applicants whose work is non-DEI-focused, because non-DEI-focused work is seen as more lucrative for the purposes of revenue generation. For non-tenure track applicants, their teaching expertise is often class-coded in terms of a hypothetical educational marketplace where such teaching philosophies are deemed as being too targeted and only applicable to a small fraction of an institution's enrollment.

Favorable and unfavorable characteristics of faculty applicants

Specific characteristics of applicants, such as their institutions and advisors, their research and teaching experiences, as well as their personal identities, may impact hiring decisions.

Differences in perspectives in faculty hiring are also influenced by organizational characteristics and the reputations of their institutions (Stainback et. al., 2010). For example, an important factor for reviewing applicants is the university the applicants attended and whether or not the university is considered to be "impressive" (Wilkens & Comfort, 2016). If an applicant's education does not come from an institution with a renowned reputation, applicants may be able to compensate for this perceived shortcoming with postdoctoral experience from a more prestigious and "impressive" institution. Designation as a Carnegie R1 institution is one that, in part, drives the perceptions of the institution. Preferences for qualifications in candidates that are research-related are likely to be largest at these institutions because research plays the largest role within R1 institutions' revenue-generation capacity compared to any other institutional type.

Studies have shown research background, and specifically publication history, is significantly important with how applicants were academically ranked. Gore et al. (1998) found that many faculty members preferred to hire applicants that had a specific focus or research area. Wilkens and Comfort (2016) indicated a strong history of research experience such as having obtained a grant, especially a grant that applicants could take to new universities, was highly desirable. Experience with this type of grant could be valuable enough to counteract other weaknesses in the application (Wilkens & Comfort, 2016). Boysen (2021) found that participants who had no publications or professional research presentations were unlikely to be considered. Committees expected applicants to have at least one publication at the time of their application (Boysen, 2021).

Teaching is another important aspect that faculty members evaluate in the hiring process. Wilkens and Comfort (2016) explained that being an instructor of record was a valuable characteristic since it showed an understanding of the demands of teaching as well as a strong history of doing so. If an applicant does not have teaching experience, Wilkens and Comfort (2016) recommended that applicants seek out adjunct teaching prior to applying for tenure track positions. In addition, Boysen (2021) found that overall, committees expected at least 2 years of teaching experience along with being responsible for a full course.

When it comes to applicants' personal identities and personal lives, factors such as gender and relationship status may influence the decisions of hiring committees. Rivera (2017) explored hiring decisions of committees and found that committees opted to hire men candidates or single women candidates over heterosexual partnered women. Rivera (2017) explained that hiring committees assumed that if a woman's partner (man) was in an impressive career, that she would not be able to move in order to begin the position as her partner's career would take priority over hers.

Applicant characteristics might also be evaluated through letters of recommendation. Rajesh et al. (2019) examined the characteristics that faculty looked for specifically within letters of recommendation for surgical residency programs and found that faculty members

ranked the top two applicant characteristics in letters of recommendation as applicants having a strong work ethic or were hard workers, and applicants being inquisitive or "hungry learners".

In addition to the studies mentioned above that discussed favorable characteristics of faculty applicants, Boysen et al. (2019) specifically discussed unfavorable characteristics for faculty applicants known as "kisses of death" in which candidates may lose out on positions to other applicants. There were seven unfavorable characteristics the study found, such as "lack of collegiality, questionable qualifications, lack of professional polish, poor preparation, lack of fit, poorly constructed materials, and lack of enthusiasm" (Boysen et al. 2019). These unfavorable characteristics may sometimes place women and/or REM applicants (particularly African Americans) in an undesirable situation because of negative competence-related stereotypes associated with their identities (e.g., the misconception that women and/or REMs are less capable in certain domains) that manifest in mischaracterizations associated with lack of fit or poor preparation. As such, women and African Americans are found to be underrepresented in fields whose practitioners believe that raw, innate talent (brilliance) is the main requirement for success, because women and African Americans are stereotyped as not possessing such brilliance (Leslie et al., 2015).

Influencing factors of applicant characteristics

Previous research outlines specific qualifications within teaching and research may be influenced by what level of institution the candidates apply for and what level of career the faculty were in (Boysen, 2021; Boysen et al., 2019). Boysen (2021) discussed the minimum qualifications in research and teaching for faculty applicants across various institution types (e.g., baccalaureate, master's, and doctoral institutions). As expected, results suggested that if an applicant was farther along in their career, the expected qualifications were increased. For example, for applicants applying to baccalaureate and master's universities, applicants who were current graduate students were expected to have one publication, while applicants from postdoctoral programs and current faculty applicants were expected to have at least two. At doctoral institutions, graduate student candidates were expected to have two publications, postdoctoral applicants were expected to have three publications, while faculty applicants were expected to have four publications at the time of applying (Boysen, 2021). Additionally, the minimum teaching qualifications varied based on type of institution. Applicants from baccalaureate and master's universities were unlikely to be given consideration if they had little to no teaching experience (e.g., had never taught a course). However, at doctoral level institutions, candidates with little to no teaching experience still could be considered.

Existing literature also suggests that who is making the hiring decisions is an important factor in determining which applicants will be hired (Tomlinson & Freeman, 2018). When examining which members of the faculty search committees were making hiring decisions for tenure track faculty applicants at graduate institutions, Tomlinson and Freeman (2018) found that the majority of the faculty search committee were faculty members (87%) and that faculty members' votes were the most important and influential in determining who would be hired, even more so than department heads and deans.

Although research concerning hiring practices was limited, there was information about the experiences of faculty at Historically Black Colleges and Universities (HBCUs) compared to predominantly white institutions (PWIs). Winkle-Wagner and McCoy (2016) examined the perceptions of faculty, graduate, and undergraduate students of color at PWIs compared to HBCUs and found that participants' perceptions were connected to their overall feelings on campus and within their academic programs. For example, participants who were students or faculty members of a PWI expressed they felt left out, and that their institutions were unsuccessful in creating a more inclusive environment. Conversely, participants who were at an HBCU reported that STEM departments were diverse, and that the institution overall was supportive of their needs as faculty and students of color (Winkle-Wagner & McCoy, 2016).

The current study

A key factor in diversity within institutions is the diversity of the faculty members who are hired, and several factors how these decisions are made by faculty search committees. To make progress in hiring decisions, it is necessary to better understand faculty hiring practices, especially how the characteristics of applicants are considered and evaluated. Therefore, we designed and conducted the current study, aiming to understand faculty search committees' practices by asking the following four research questions to explore the related hypotheses derived from our review of the literature:

1. When evaluating applicants for STEM faculty positions, what levels of importance do search committee members place on institutional and advisor characteristics, applicant characteristics, and applicant qualifications?

    - Hypothesis 1a. Respondents from R1 institutions place higher levels of importance on reputational

factors associated with institutional and advisor characteristics than those from non-R1 institutions.
- Hypothesis 1b. Respondents from Minority Serving Institutions (MSIs) place higher levels of importance on applicant characteristics associated with diversity than those from non-MSI institutions.
- Hypothesis 1c. Respondents from non-R1 institutions place higher levels of importance on applicant qualifications related to teaching and service than those from R1 institutions.

2. Do the levels of importance of institutional and advisor characteristics, applicant characteristics, and applicant qualifications differ when search committees are evaluating tenure track and non-tenure track faculty applicants? If so, how?

   - H_0: There is no difference in the levels of importance placed on institutional and advisor characteristics, applicant characteristics, and applicant qualifications when evaluating tenure track and non-tenure track applicants.
   - H_a: There are significant differences in the levels of importance placed on institutional and advisor characteristics, applicant characteristics, and applicant qualifications when evaluating tenure track and non-tenure track applicants.
   - We further hypothesized that teaching- and service-related qualifications are more important for non-tenure track applicants and research-related qualifications are more important for tenure track applicants.

3. Do factors such as faculty members' institution, position, and personal identity affect how they evaluate applicants, both for tenure track positions and non-tenure track positions?

   - H_0: There is no significant difference in evaluation based on personal and institutional characteristics of respondents.
   - H_a: There are significant differences in evaluation based on personal and institutional characteristics of respondents.

4. Does the level of importance of applicant qualifications differ when adding in diversity, equity, and inclusion (DEI) related constructs, both for tenure track positions and non-tenure track positions?

   - H_0: There is no significant difference in the level of importance when adding in DEI-related constructs.
   - H_a: There are significant differences in the level of importance when adding in DEI-related constructs.

Methods

The data for this study were collected as part of a larger project designed to advance equity for individuals from racially and ethnically minoritized (REM) identities entering the STEM professoriate in disciplinary areas related to Data Engineering and Sciences (DES). Part of the project involved understanding factors that impact the faculty hiring process. In this study, we examined how incumbent STEM administrators and faculty members with experience on search committees viewed the comparative importance of a variety of potential applicant characteristics and qualifications in their evaluation of prospective faculty members. We also examined how—or if—those views varied based on the incumbents' professional (e.g., institution, academic rank) or personal (e.g., race, ethnicity, gender) identities and the nature of the positions themselves (tenure track versus non-tenure track).

We used a web-based survey as the principal tool to gather information from current STEM faculty members and administrators. The survey was derived based on literature on faculty hiring (e.g., Boysen et al., 2019; Sensoy & DiAngelo, 2017), our previous research on job announcements (Boyle et al., 2020), and input from our project's research advisory board. The research advisory board included three faculty members: one full professor in sociology at a public R1 university whose expertise is social stratification and inequality; one associate professor of computer science at a public R1 Hispanic Serving Institution (HSI) whose expertise includes equitable engagement in engineering and computer science; and an assistant professor of education at public R1 institution whose research is focused on access and equity in higher education. All three advisory board members' work includes intersections of race/ethnicity and gender along with other dimensions of social inequalities. The survey was originally deployed in early Fall 2020 via professional networks that included community and committee listservs in organizations such as the American Society of Civil Engineers, American Society for Engineering Education and participants in nationwide National Science Foundation (NSF)-funded workshops that included faculty across multiple STEM disciplines.

Because the institution types and personal demographics were not representative of STEM programs nationally, we enlisted the support of the American Association for the Advancement of Science (AAAS), and in late Fall 2020, distributed the survey to a large network of STEM faculty through the listserv of one of its programs, thereby increasing the number and diversity of respondents.

Participants

The overall survey received 216 responses. Because our goal for the current study was to examine and compare factors that impact STEM faculty members' recommendations when considering new faculty hires for tenure-track and non-tenure track positions, the sample for this study was limited to those who completed all the questions on applicant characteristics and qualifications for both tenure track and non-tenure track hiring. Ultimately, we analyzed responses from a sample of 103 participants for this study. We asked respondents to indicate whether or not they had served on faculty search committees or provided input on applicants for faculty positions in their department/program. Only those who responded "yes" were included. We did not ask them the amount of time since their last participation on a search committee; one of the aims of the survey was to be as inclusive as possible to capture people whose academic track may have changed, such as someone who switched from tenure track to non-tenure track or administration.

Of the 103 respondents, there were 60 men (58.3%) and 43 women (41.7%). We included other gender identity options in the survey (transgender, non-binary) along with an opportunity for respondents to indicate a gender identity that was not listed, that they preferred not to respond, as well as an option to check all that apply; however, this sample of respondents only identified with binary genders. In terms of race and ethnicity, 63.1% were White ($n=65$), 21.4% were Black or African American ($n=22$), 9.7% were Asian ($n=10$), 9.7% were Hispanic or Latinx ($n=10$), and the rest (5.8%) were two races or more, a race not listed, or preferred not to answer. Therefore, taking both race and ethnicity into account, 33% of the sample were from historically underrepresented racially and ethnically minoritized (REM) identities in STEM ($n=34$); 67% were not ($n=69$). A total of 3.9% ($n=4$) of respondents identified as having a disability. Regarding employment, a little over half (50.5%, $n=52$) of the sample were currently employed at Minority Serving Institutions (MSIs). Just under half of the sample (44.7%, $n=46$) were currently employed at Doctoral Institutions: Very High Research Activity (R1) based on Carnegie Classification. In addition, 22.3% of the respondents ($n=23$) held administration positions (e.g., dean, associate dean, department chair) at their institutions. A detailed breakdown of the participants' demographics can be found in Table 1.

Table 1 Demographic characteristics of the participants

Sample characteristics	*n*	%
Total	103	100
Gender		
Men	60	58.3
Women	43	41.7
Race		
White	65	63.1
Black	22	21.4
Asian	10	9.7
Black, White	1	1.0
A race not listed here	2	1.9
Black, A race not listed here	1	1.0
I prefer not to answer	2	1.9
Ethnicity		
Hispanic or Latinx	10	9.7
Not Hispanic or Latinx	93	90.3
Disability		
Yes	4	3.9
No	98	95.1
I prefer not to answer	1	1
Minority Serving Institutions (MSI)		
HSI	25	24.3
HBCU	21	20.4
ANNH	1	1.0
AANAPISI	5	4.9
Not MSI	51	49.5
Current Institution's Carnegie Classification		
Doctoral Universities: Very High Research Activity	46	44.7
Doctoral Universities: High Research Activity	22	21.4
Doctoral/Professional Universities	5	4.9
Master's Colleges and Universities	18	17.5
Baccalaureate Colleges	8	7.8
Baccalaureate/Associate's Colleges	2	1.9
Associate's Colleges	2	1.9
Academic position		
Tenure track faculty	15	14.6
Tenured faculty	55	53.4
Non-tenure track faculty	10	9.7
Administration	23	22.3

Instrument

Our overall survey included a series of multiple choice, short answer, and rank order items that covered a variety of aspects that play a role in faculty hiring decisions. In this paper, we only include survey items that are relevant to the research questions for the current study.

Specifically, we describe in detail items related to institution and advisor characteristics, applicant characteristics, applicant qualifications, and additional demographic information on identity and employment. We asked the same sets of questions asked for both entry-level tenure track and entry-level non-tenure track faculty positions. Appendix contains a list of items we included in the current study.

To establish construct validity, we performed cognitive interviews as described by Haeger et al. (2012) and Willis and Artino (2013). We piloted our survey with 14 participants who identified as non-tenure track, tenure track, or tenured STEM professors, asking them to share their thoughts on survey items as they answered them. We also included structured prompts to elicit responses. A crucial area we identified prior to piloting were items that included DEI terms or concepts, and indeed, participants often did not interpret our questions as intended. We spent time in conversation with participants whose interpretations differed from our intent until we reached an understanding about the language in the survey items. We then redrafted survey items before final distribution. At each stage, we conferred with our research advisory board, and they strongly supported our final instrument.

Institutional and advisor characteristics

We were interested in which institutional and advisor characteristics incumbent faculty members considered more or less important when evaluating applicants. We asked participants to use a five-point Likert scale (1 being not at all important and 5 being extremely important) to rate the importance of each of nine characteristics of applicants' institutions and advisors to their positive evaluation of an applicant for an entry-level faculty position in their department. This set of questions was asked for both tenure track and non-tenure track faculty positions.

Characteristics included the rankings of the institutions and departments where applicants earned their undergraduate degree, where they earned their doctoral degree, and where they completed postdoctoral appointments; the research reputations of the applicant's doctoral advisor and postdoctoral sponsor; and the diversity of the applicant's undergraduate institution. Cronbach's alpha coefficients (internal consistency reliability) for the items were calculated and they exceeded acceptable levels, with all over 0.83 for the tenure track questions and all over 0.86 for the non-tenure track questions.

Applicant characteristics

In addition to institutional and advisor characteristics, we were also interested in the importance of applicant characteristics in the evaluation of applicants for faculty positions. Using the same five-point Likert scale as before, for both tenure track and non-tenure track entry-level faculty positions, we asked participants to rate the importance of each of 11 applicant characteristics to their positive evaluation of an applicant for an entry-level faculty position in their department. The characteristics covered a range of items that span teaching, research, and service as well as identity-related questions that were included to help us identify possible biases toward or against applicants from certain groups. They included items related to the applicant's experience as a postdoctoral researcher and in teaching in their field; their publication of articles in reputable journals and articles that challenge norms in their field; whether or not the applicant worked with researchers from disciplines other than their own and with researchers from disciplines other than engineering or natural sciences; whether or not the applicant worked with people of different races and/or ethnicities other than their own and with people of different genders than their own; whether or not the applicant identifies as a person from a historically underrepresented identity in STEM, namely racially/ethnically minoritized identity, as a woman, or as a person with a disability. Acceptable internal consistency reliabilities were also obtained for the applicant characteristics items, with all alphas over 0.7.

Applicant qualifications

Regarding applicant qualifications, we were interested in examining those that centered around important aspects of faculty job responsibilities—teaching, research, and service—as well as those that focused on culture and climate in the program/institution.

We asked participants: *How would you rank the relative importance of each of the following applicant qualifications for an entry-level faculty position in your department? Consider 1 as most important and 7 as least important, relative only to the items listed.* Items we included in the survey were:

- ability to contribute to an inclusive climate in the department;
- ability to advise and mentor students;
- ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs;
- ability to deliver high quality teaching;
- ability to implement inclusive teaching strategies (e.g., universal design for learning, culturally relevant pedagogy) in their courses;
- ability to secure external funding; and
- ability to secure external funding to support the inclusion of people from historically underrepre-

sented groups (e.g., women, people with disabilities, historically underrepresented racial and ethnic minorities).

One important idea behind the presentation of these qualifications is how DEI-related constructs are incorporated. For example, both the second and third items are about working with students, but the third specifies working with historically underrepresented racial and ethnic minority students. Similarly, both the fourth and fifth items are about teaching, with the fifth paying particular attention to inclusive teaching strategies. The sixth and seventh items are paired following a similar logic. The order of the items presented was randomized for each participant to control for the order effect. Again, we asked this set of ranking questions for both tenure track and non-tenure track hiring considerations.

Demographic information

In addition to the characteristics and qualifications, we also collected demographic information from our participants. We included items on participants' personal identities, such as gender, race, ethnicity, disability, as well as their employment, including their current institution, current position, etc. In line with the definition of historically underrepresented minority groups from the National Science Foundation (NSF), we created a new variable called "URM" using information from both race and ethnicity to capture the status of underrepresented racial and ethnic minorities, which include Blacks/African Americans, Hispanic/Latinx, American Indians, Alaska Natives, Native Hawaiians, and Native Pacific Islanders. For information on participants' currently employed institution, we took an additional step to look up the institution's MSI status and its Integrated Postsecondary Education Data System (IPEDS) ID to determine the institution's Carnegie Classification.

Data analysis

All the data cleaning and statistical analyses were carried out using Jamovi (2021), an open-source statistics software based on the R programming language (2021). We computed descriptive statistics (i.e., mean, median, and standard deviation) for the study variables. Because the data did not meet normality assumption for parametric testing, we analyzed group comparisons between gender, race and ethnicity, current institution, and current position using the Mann–Whitney test, and comparisons within the same participants for tenure track hiring and non-tenure track hiring using the Wilcoxon ranked sum test. According to de Winter and Dodou (2010), Mann–Whitney–Wilcoxon tests and t-tests have equivalent power on Likert items, but Mann–Whitney–Wilcoxon has a power advantage when sampled from a skewed or peaked distribution. Therefore, Mann–Whitney–Wilcoxon tests were more appropriate for our study to produce reliable results. We also ran all the analyses with t-tests (independent two-sample and paired sample) and obtained the same results.

Results

Importance of institutional and advisor characteristics, applicant characteristics, and applicant qualifications in tenure track and non-tenure track STEM faculty hiring

We present our findings from our results for the first two research questions: When evaluating applicants for STEM faculty positions, what levels of importance do search committee members place on institutional and advisor characteristics, applicant characteristics, and applicant qualifications? Do the levels of importance of institutional and advisor characteristics, applicant characteristics, and applicant qualifications differ when search committees are evaluating tenure track and non-tenure track faculty applicants? If so, how?

Importance of institutional and advisor characteristics was examined using a five-point Likert scale (1 being not at all important and 5 being extremely important). Figure 1 summarizes the mean values of responses along with hypothesis testing results of institutional and advisor characteristics for both tenure track and non-tenure track hiring. In general, characteristics about the applicant's doctoral institution (including institutional and advisor characteristics) are more important, and characteristics about the applicant's undergraduate institution are less important, regardless of tenure track or non-tenure track hiring. We performed a Wilcoxon rank sum test to examine the difference between tenure track and non-tenure track hiring considerations within the same respondents, and we found that respondents view characteristics about applicants' postdoctoral appointment and doctoral degree significantly more important in tenure track hiring compared to non-tenure track hiring. Such statistically significant results ($p < 0.001$) hold true for all six items on postdoctoral and doctoral institutional and advisor characteristics. On the contrary, characteristics about undergraduate degree appear to be more important in non-tenure track hiring, compared to tenure track hiring, with the difference for "the ranking of the department from which the applicant earned their undergraduate degree" being the most significant ($p < 0.01$). Detailed descriptive data and hypothesis testing results are available in Additional file 1: Table S1.

The importance of applicant characteristics was also examined using a five-point Likert scale. Figure 2 presents the mean values of responses along with hypothesis testing results of applicant characteristics considered for

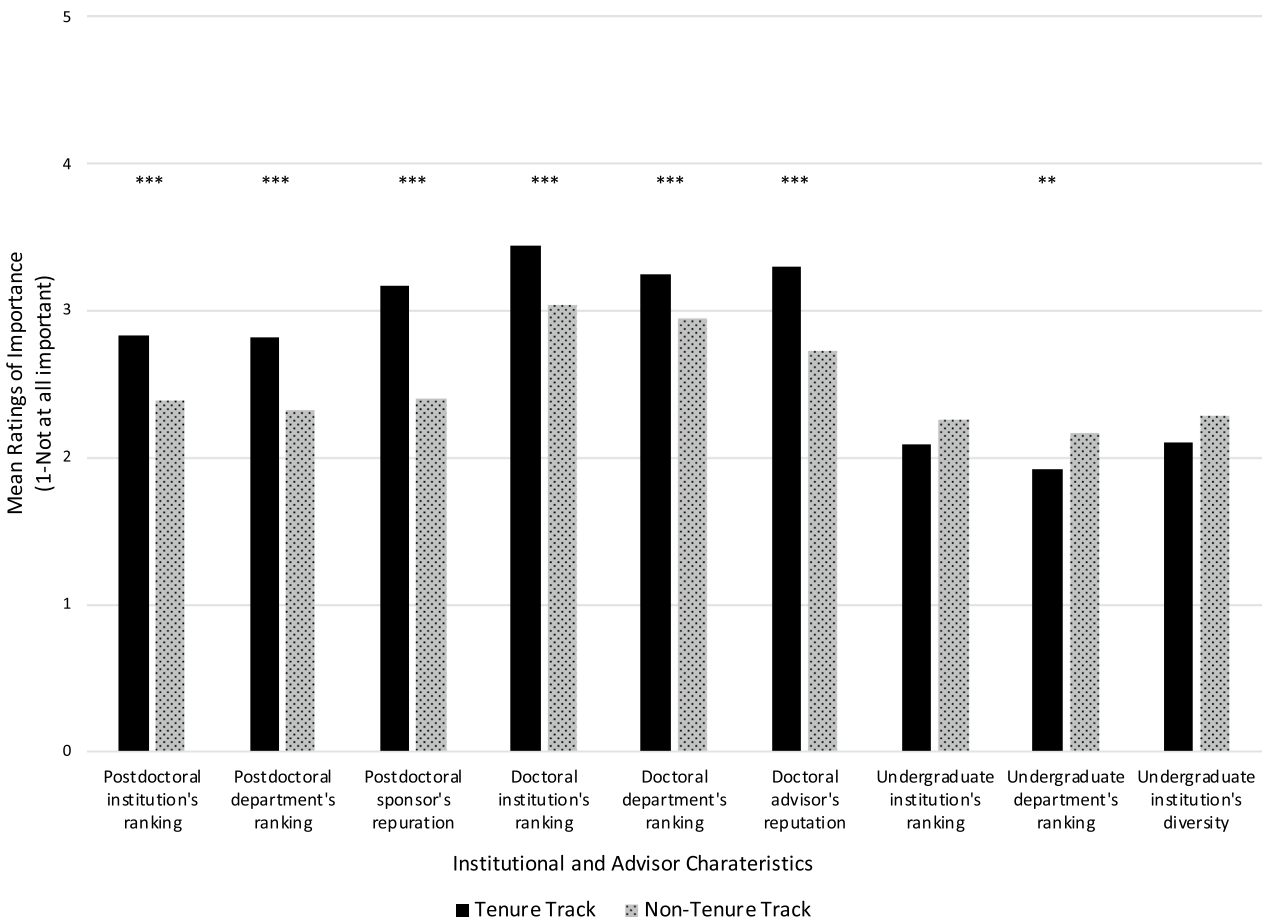

Fig. 1 Ratings of importance of institutional and advisor characteristics

both tenure track and non-tenure track hiring. Overall, we found that respondents' perspectives on tenure track hiring and non-tenure track hiring differed significantly. For tenure track hiring, an applicant's publication record ("the applicant has published articles in reputable journals in their discipline") appears to be the most important characteristic among all the applicant characteristics ($M = 4.26$, SD = 0.87). For non-tenure track hiring, the applicant's teaching experience ("the applicant has teaching experience in their discipline") stands out as the most important one ($M = 4.00$, SD = 1.2). When comparing applicant characteristics side-by-side for tenure track versus non-tenure track using Wilcoxon rank sum test, we found that respondents viewed items related to research as more important for tenure track hiring and items related to teaching and diversity as more important for non-tenure track hiring. Specifically, applicants' postdoctoral experience, publication record, and research experience with researchers from other disciplines are deemed more important for tenure track than non-tenure track, and the differences are statistically significant. Applicant's teaching experience and experience working with diverse people (race/ethnicity, gender) are deemed more important for non-tenure track than tenure track, and the differences are also statistically significant. However, we did not find a difference in the importance of applicant's own identity (race/ethnicity, gender, disability) in tenure track versus non-tenure tracking hiring. Detailed descriptive data and hypothesis testing results can be found in Additional file 1: Table S2.

The importance of applicant qualifications was evaluated based on a 1–7 ranking, with 1 referencing the most important and 7 referencing the least important. Figure 3 shows the mean values of responses for each of the applicant qualifications and the hypothesis testing results comparing tenure track and non-tenure track hiring. The ability to deliver high-quality teaching turned out to be the most important qualification in both tenure track and non-tenure track faculty hiring. In tenure track hiring, the ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs was ranked the least important

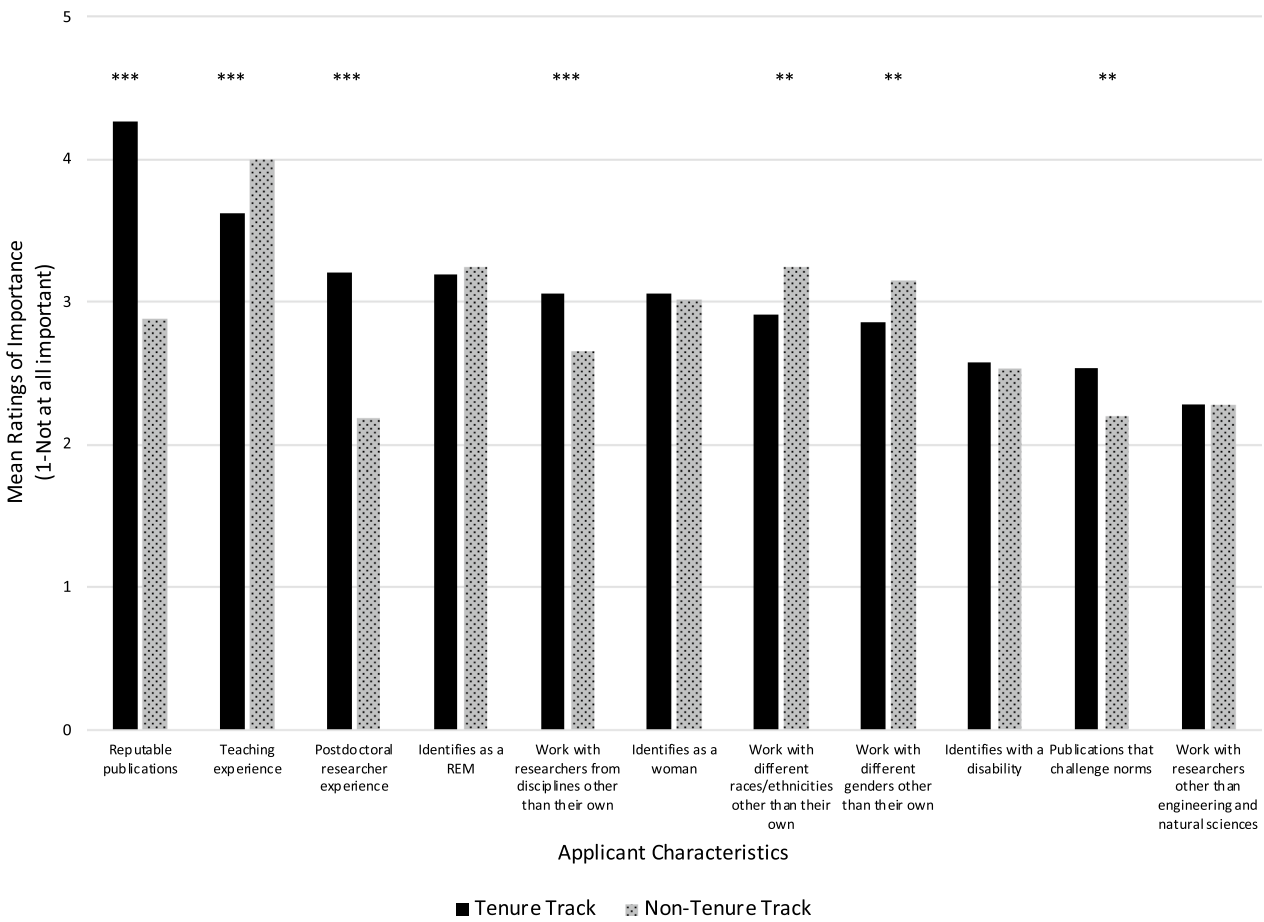

Fig. 2 Ratings of importance of applicant characteristics

qualification; whereas in non-tenure track hiring, ability to secure external funding was ranked as least important. We tested the differences regarding applicant qualifications between tenure track and non-tenure track hiring using Wilcoxon rank sum test, and we found that teaching abilities (both "ability to deliver high quality teaching" and "ability to implement inclusive teaching strategies in their courses") are considered significantly more important in non-tenure track hiring than tenure track hiring, whereas abilities to secure funding (both "ability to secure external funding" and "ability to secure external funding to support the inclusion of people from historically underrepresented groups") are considered significantly more important in tenure tracking hiring than non-tenure track hiring. We did not find significant differences in "ability to advise and mentor students", "ability to contribute to an inclusive climate in the department", and "ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs". However, "ability to advise and mentor students" was ranked more important for non-tenure track than tenure track, where as "ability to contribute to an inclusive climate in the department", and "ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs" were ranked more important for tenure track than non-tenure track. Detailed descriptive data and hypothesis testing results are included in Additional file 1: Table S3.

Impact of faculty member's professional and personal identities on evaluation of faculty hires

To answer the third research question, we examined the effect of respondents' institution, position, and personal identities on evaluating faculty hires, by performing Mann–Whitney U tests to determine the between-group differences. Specifically, we looked at respondents' institution (R1 vs. non-R1, MSI vs. non-MSI), position (administrative vs. non-administrative), gender (man vs. woman), and race/ethnicity (URM vs. non-URM), and we present our results for these analyses.

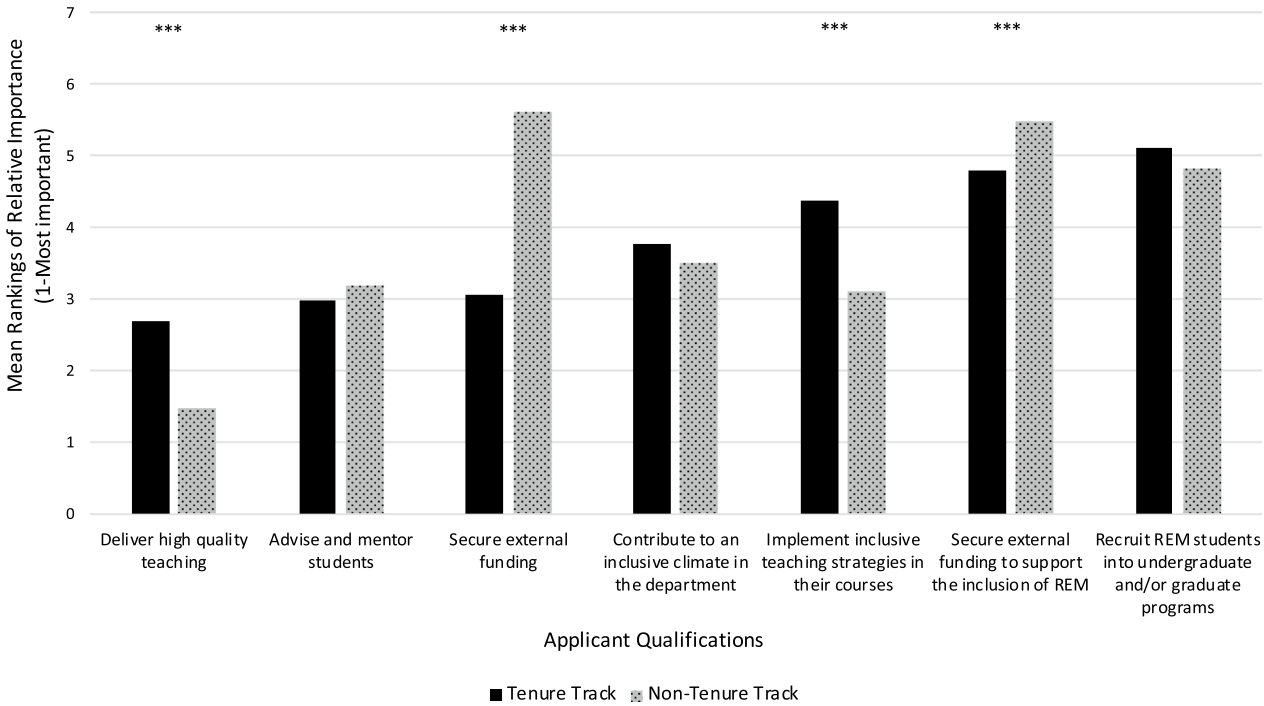

Fig. 3 Ranking of relative importance of applicant qualifications

Institution

We first differentiate respondents by their currently employed institutions' Carnegie Classification into R1 (Doctoral Institution—Very High Research Activity) and non-R1 (all other Basic Carnegie Classifications). For tenure track hiring, we found that respondents from R1 institutions viewed the research reputation of the post-doctoral sponsor ($U=842$, $p<0.001$) and the research reputation of the doctoral advisor ($U=884$, $p<0.001$) significantly more important than those from non-R1 institutions, and they considered the diversity of the undergraduate institution ($U=885$, $p<0.001$) significantly less important. We also found that respondents from R1 institutions placed significantly more importance on whether the applicant has published articles in reputable journals in their discipline ($U=807$, $p<0.001$), and they considered teaching and diversity-related applicant characteristics—teaching experience in their discipline ($U=486$, $p<0.001$), has worked with people of different races and/or ethnicities other than their own ($U=866$, $p<0.001$), and has worked with people of different genders than their own ($U=812$, $p<0.001$)—significantly less important. In addition, we found significant differences in the following applicant qualifications: the ability to deliver high-quality teaching ($U=761$, $p<0.001$), the ability to secure external funding ($U=569$, $p<0.001$), the ability to implement inclusive teaching strategies in their courses ($U=778$, $p<0.001$). Respondents from R1 institutions considered teaching-related qualifications significantly less important than their non-R1 counterparts, and they indicated that the ability to secure external funding is significantly more important.

We also differentiated respondents by their institutions' MSI status and examined the impact of that on faculty hiring evaluations. The only significant difference in tenure track hiring is the ranking of the undergraduate department ($U=1016$, $p<0.05$), which is considered to be significantly more important by faculty members from MSIs.

When it came to non-tenure track hiring, respondents' institutions made little difference. The only statistically significant difference we found between R1 and non-R1 respondents was the research reputation of the doctoral advisor ($U=878$, $p<0.001$), which was considered to be more important by respondents from R1 institutions. We also only found one statistically significant difference between respondents from MSIs and non-MSIs, which was that the applicant has published articles that challenge norms in their discipline ($U=993$, $p<0.05$). Respondents from MSIs considered this applicant characteristic to be significantly more important than their non-MSI counterparts.

Position

For tenure tracking hiring, the only significant difference we found regarding respondents' position was that administrators placed significantly more importance on whether the applicant identifies as a historically underrepresented racial/ethnic minority ($U=668$, $p<0.05$) than non-administrator faculty respondents.

For non-tenure track hiring, the only significant difference we found with regard to respondents' position is that administrators considered the research reputation of the postdoctoral sponsor ($U=660$, $p<0.05$) to be significantly less important than non-administrator respondents.

Gender

For tenure track hiring, we found that men found the following institutional and advisor characteristics significantly more important than women: the research reputation of the doctoral advisor ($U=986$, $p<0.05$), the ranking of the undergraduate institution ($U=833$, $p<0.001$), the ranking of the undergraduate department ($U=1003$, $p<0.05$), and the diversity of the undergraduate institution ($U=1010$, $p<0.05$). We also found that men placed significantly more importance on applicant characteristics such as: the applicant has published articles that challenge norms in their discipline ($U=970$, $p<0.05$), the applicant identifies as a historically underrepresented racial/ethnic minority ($U=960$, $p<0.05$), and the applicant identifies as a woman ($U=915$, $p<0.001$). In addition, we found women considered the ability to implement inclusive teaching strategies in their courses more important than men ($U=956$, $p<0.05$).

For non-tenure track hiring, only two items turned out to be significantly different in gender comparison: the applicant has worked with people of different races and/or ethnicities other than their own ($U=998$, $p<0.05$), and the ability to implement inclusive teaching strategies in their courses ($U=895$, $p<0.001$). In both cases, women consider the items to be significantly more important than their men counterparts.

Race and ethnicity

For tenure track hiring, we found that faculty members who identify with racially and/or ethnically minoritized groups viewed the following institutional and advisor characteristics significantly more important than those who do not: the ranking of the doctoral institution ($U=739$, $p<0.001$), the ranking of the doctoral department ($U=878$, $p<0.05$), and the research reputation of the doctoral advisor ($U=896$, $p<0.05$). We also found that minoritized faculty members place more importance on whether the applicant identifies as a historically underrepresented racial/ethnic minority ($U=902$, $p<0.05$), and whether the applicant identifies as a woman ($U=894$, $p<0.05$).

For non-tenure track hiring, only two items turned out to be significantly different in race/ethnicity comparison: the applicant has postdoctoral experience ($U=863$, $p<0.05$) and the ability to secure external funding to support the inclusion of people from historically underrepresented groups ($U=891$, $p<0.05$). In both cases, faculty members who themselves are from racially and/or ethnically minoritized identities considered the items to be significantly more important than those who are not.

Differences when introducing diversity, equity, and inclusion (DEI) constructs

As introduced in the methods section, one important decision we made when designing the qualifications items in our survey instrument was the addition of DEI-related constructs, in particular, those that would help identify biases. To answer the fourth research question, respondents were asked to rank the relative importance of several applicant abilities that cover the areas of teaching, research, and service using a scale from 1 to 7, with 1 being most important and 7 being least important.

We performed Wilcoxon rank sum test to determine whether the addition of DEI constructs made a difference in the following paired items: ability to advise and mentor students versus ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs (advise and recruit); ability to deliver high-quality teaching versus ability to implement inclusive teaching strategies in their courses (teaching); ability to secure external funding versus ability to secure external funding to support the inclusion of people from historically underrepresented groups (secure funding). We tested the differences for both tenure track and non-tenure track hiring evaluations.

For both tenure track and non-tenure track evaluations, qualifications with DEI constructs added were rated as significantly less important than their paired items without DEI constructs. For example, "ability to deliver high quality teaching" was rated as highly important ($M=2.69$) while "ability to implement inclusive teaching strategies in their courses" was rated as significantly less important ($M=4.37$). In all except one case, the qualifications with DEI constructs turned out to be significantly less important; the only item that was not statistically different was the "secure funding" item as applied to non-tenure track hiring. Table 2 shows the breakdown of each pair's descriptive statistics and the Wilcoxon W statistics.

Table 2 Descriptive statistics for qualifications with and without DEI constructs

Qualifications	Regular *M* (SD)	DEI constructs *M* (SD)	Wilcoxon W	*p*
Tenure track				
Advise and recruit	2.98 (1.69)	5.10 (1.82)	498	***
Teaching	2.69 (1.79)	4.37 (1.93)	812	***
Secure funding	3.05 (2.07)	4.80 (1.70)	834	***
Non-tenure track				
Advise and recruit	1.49 (1.12)	3.11 (1.57)	472	***
Teaching	3.18 (1.44)	4.83 (1.56)	758	***
Secure funding	5.60 (1.75)	5.48 (1.43)	2724	

SD: standard deviation

***$p < 0.001$—statistically significant; **$p < 0.01$—statistically significant; *$p < 0.05$—statistically significant

Discussion

The purpose of this study was to gain a better understanding of the STEM faculty hiring process through an examination of applicant qualifications and characteristics as seen by incumbent STEM faculty and administrators who engage in search processes. There were three key findings from this study. First, we found that faculty members placed distinct levels of importance on characteristics and qualifications for tenure track hiring and non-tenure track hiring. As expected, items related to research appeared to be more important when evaluating applicants for tenure track positions, whereas items related to teaching and diversity appeared to be more important when evaluating non-tenure track applicants. Second, faculty members' institution, position, and personal identities (e.g., gender, race/ethnicity) had an impact on how they evaluated applicants. Third, when introducing DEI-related constructs as part of applicant qualifications, faculty members rated almost all of the items significantly less important, and this trend holds true for both tenure track and non-tenure track hiring.

As presented in our findings for applicant qualifications (research questions 1 and 2), our results clearly suggest that research and teaching are important aspects in the STEM faculty hiring process. This pattern of results is consistent with previous literature that showed research background was significantly important with how applicants were ranked (e.g., Boysen, 2021; Gore et al., 1998; Wilkens & Comfort, 2016) and that teaching record was valuable and was expected from applicants (e.g., Boysen, 2021; Wilkens & Comfort, 2016). Our results further demonstrated that the importance of research and teaching could vary significantly between tenure track hiring and non-tenure track hiring. This finding may be explained by the idea that responsibilities and expectations of tenure track and non-tenure track faculty are different. For example, Boysen (2021) discussed the minimum qualifications in research and teaching for faculty applicants across various institution types (e.g., bachelor's, master's, and doctoral institutions). Cavanaugh and Green (2020) also noted differences between the needs of tenure system faculty and non-tenure system faculty when implementing training for hiring committees. The creation of trainings was heavily influenced by arts and sciences in which tenure track faculty members are the majority, so the information provided in the trainings was directly applicable to tenure system faculty. However, when the trainings were utilized in the nursing department where the majority of faculty were non-tenure system, Cavanaugh and Green (2020) found that these trainings no longer served the needs. The differences between criteria for tenure track and non-tenure track hiring demonstrated in our current study have implied that the academe should develop clearer criteria and trainings for different hiring needs. Furthermore, emphasizing research reputation and postdoctoral reputation while neglecting institutional diversity creates problems for racial diversity because biases—both implicit and explicit, both positive and negative—still exist.

In response to research question 3 on the effect of faculty institutions and identities, our results also strongly evidenced that institution, position, and personal identities could affect how faculty members position themselves in the hiring committee and subsequently affect their evaluations. For instance, our findings suggested that faculty from Carnegie R1 (Doctoral—Very High Research Activity) institutions tend to view applicants' postdoctoral and doctoral experience more importantly, compared to applicants' undergraduate experience. R1 faculty also placed more importance on characteristics and qualifications related to research, but less importance on characteristics and qualifications related to teaching and diversity. Although no previous research directly hiring committee members' institutions to our knowledge, this pattern of results is in fact consistent with past studies that showed specific qualifications within teaching and research may be influenced by what level of institution the candidates apply for (e.g., Boysen, 2021; Boysen et al., 2019). Moreover, our findings highlighted how gender and race/ethnicity of members of the hiring committee impact how characteristics and qualifications are evaluated. It is interesting that we found men considered the diversity of the undergraduate institution, as well as if the applicant identifies as a woman or a historically underrepresented racial/ethnic minority more important than their women counterparts. One interpretation

of such findings is that respondents might be affected by social desirability bias where they tend to ascribe themselves to traits that are socially desirable (Hoffmann & Musch, 2019; Nederhof, 1985). As the academe increasingly advocates more for diversity and equity, some men faculty might want to show their support by overrating the importance of diversity and equity related items in our survey instrument because they knew that they were being examined and researched. It is also possible that women have less equitable and inclusive views, partly due to competition induced by tokenism where women are competing with other women for limited positions on the faculty team and they therefore become more hesitant to bring in other women colleagues. Our results also suggested that minoritized faculty members placed more importance on whether the applicant identifies as a historically underrepresented racial/ethnic minority or whether the applicant identifies as a woman. An explanation to this result can be in-group bias or in-group favoritism—the tendency for people to give preferential treatment to others who belong to the same group that they do (Friedmann & Efrat-Treister, 2023; Taylor & Doria, 1981). In the context of our research, faculty members who themselves are minorized in STEM might favor applicants who are also underrepresented in STEM disciplines. Moreover, our results were consistent with research on bias in recruitment (Russell et al., 2019), revealing that affinity bias (preference for sameness), confirmation bias (tendency to believe perspectives that are consistent with our preconceived beliefs), and halo bias (tendency to assume an individual who exhibits one positive quality will also outperform overall) do exist in the faculty hiring process. These biases contribute to inequities in hiring and need to be addressed before we can reach and sustain desired levels of diversity.

Our findings on the significantly decreased levels of importance after bringing in DEI-related constructs (research question 4) are eye-opening, yet not surprising. Because increased diversity is often misconstrued as a decrease in quality and disconnected from how excellence is perceived and measured, it was not surprising that responses would illuminate this dichotomy. What is interesting is how consistent the trend is across almost all three areas—teaching, research, and service—for both tenure track and non-tenure track faculty hiring. Additional research is needed before a full understanding of the nuances can be laid out. We are conducting further data collection and analyses to help explain how respondents perceive and understand these constructs and why they evaluate them differently.

Limitations and future directions

There are a few potential limitations concerning the results of this study that could be addressed in future research. One limitation is that we were constrained in our sample by the limited resources and personal and professional networks we had. For example, we had to group different racial and ethnic groups together into a single variable in our analysis due to the limited number of respondents we had for each individual racial and ethnic group. We feel that a breakdown of different groups might lead to a more nuanced understanding of how diversity and equity is understood and enacted by faculty members in the hiring process. Another limitation is that almost half (44.7%) of our participants were employed at R1 institutions, indicating we oversampled R1s based on their national presence, which, according to IPEDS is 1.3% of U.S. institutions. Though this oversampling might limit the generalizability of our results to some extent, we believe it is compensated for, in part, by the fact that R1s employ 29% of all tenure system faculty and 37% of all non-tenure system faculty.

Our survey analyses provided evidence for our research questions, but additional investigations are needed to understand the underlying mechanisms and explanations associated with our findings. This may be addressed in future research that asks some "why" questions through a qualitative approach to dig deeper into these issues. We are currently engaged in some of this work. For example, while our survey did not capture how long it had been since respondents served on search committees, our interviews, which are not part of the study presented in this paper, have probed into those questions, as it is important to understand how search and hiring practices have evolved over time. We are also investigating more deeply the dichotomy between the importance of DEI-related and non-DEI-related constructs that emerged in our quantitative findings. Additionally, the present study represents our first attempt to address the issue of STEM faculty diversity through an investigation of how hiring committee members evaluate applicant characteristics and qualifications, and we treated STEM as a monolithic category like many of the previous research studies (Ehrlinger & Dunning, 2003; Park et al., 2011). However, it would be useful to examine the differences among STEM disciplines because we know that some STEM fields are doing better on gender equity, racial equity, and representational diversity than others.

Finally, future research should examine the role intersectionality plays in STEM faculty hiring. Research indicates that women of color have unique experiences in academia and are often perceived negatively by their

peers (Corneille et al., 2019; Crenshaw, 1989; Croom & Patton, 2011; Main et al., 2022; Turner, 2002). An approach centering the intersectionality of faculty candidate identities would be helpful in understanding how hiring committees evaluate women of color. Moreover, it would help illuminate biases of hiring committees so that we can continue to develop and build upon current strategies for equitable hiring.

Despite these limitations, the current research contributes to the field of higher education by providing insights into the STEM faculty hiring process through the lenses of search committee members who are faculty and administrators. We hope that our study will stimulate further investigation of this important area.

Implications and recommendations

This study was designed to examine factors that might bias incumbent faculty against (negative bias) or toward (positive bias) faculty applicants and how those factors vary based on incumbent faculty backgrounds and characteristics. Our aim is to heighten awareness so institutions can identify and address these factors when and where they emerge in their recruiting and hiring practices. We recognize decisions about faculty hiring are made by people at different levels, and this varies by institution. For this reason, we offer the following set of recommendations without delineating responsibility, with hopes readers can adopt or adapt them in a way that works in their institutional contexts:

- Standardize a process for faculty hiring that includes checkpoints at various stages that require examination of and accountability for the diversity of the applicant pool, interview pool, and candidate pool. Having a department/program head, dean, or equivalent hold committees accountable by requiring them to "go back to the drawing board" if the pools at a given stage are not representative of the terminal degree recipients in the discipline should help mitigate the challenges of power dynamics reported by Liera and Hernandez (2021) and Sensoy and DiAngelo (2017).
- Make sure people involved in faculty searches are clear on the goals for the program/department and for the position that is advertised. Create job announcements that align with those goals and are clear regarding qualifications and expectations for the position, including those related to DEI (e.g., ability to teach and advise students from a range of backgrounds and identities; expectations for equitable and inclusive research practices). This includes consideration of what "counts" as research (i.e., valuing disciplinary or multidisciplinary research with DEI-related implications on par with research that does not address DEI).
- To minimize bias and criteria creep, create rubrics that measure the criteria stipulated in the job announcement **before** viewing any applications and ensure each applicant (i.e., those who meet the minimum, completely objective "yes/no" qualifications) gets an equitable review using the rubrics. Distribute applications in a manner that spreads the workload across the search committee while ensuring more than one committee member reviews each application and that there are group discussions so decisions are less likely to be impacted by one or two people's biases.
- Create a required educational program for faculty search committee members and administrators that includes hands-on practice applying knowledge about biases, pool certification processes, and use of the rubrics. Steps should be taken to mitigate the challenges that have resulted from required trainings as described by Cavanaugh and Green (2020).

Conclusions

This study was an attempt to address the issue of diversity in STEM higher education faculty by examining how the characteristics of applicants are considered and evaluated in the faculty hiring practices. We gathered information through a web-based survey that was administered to current STEM faculty members and administrators who have experience in faculty searches. We revealed some interesting results regarding search committee members' evaluation of institutional and advisor characteristics, applicant characteristics, and applicant qualifications in STEM faculty applications. Specifically, there are three key findings of the present research: (1) respondents placed distinct levels of importance for characteristics and qualifications on tenure track hiring and non-tenure track hiring; (2) respondents' institution, position, and personal identities (e.g., gender, race/ethnicity) had an impact on their evaluating criteria; and (3) respondents rated almost all items containing DEI constructs as significantly less important than similar items (unrelated to DEI) when considering faculty applicant qualifications. Emphasizing research reputation and postdoctoral reputation while neglecting institutional diversity and equitable and inclusive teaching, research and service create problems for racial diversity because biases—both implicit and explicit, both positive and negative—still exist. These biases contribute to inequities in hiring, and need to be addressed before we can reach, sustain and grow desired levels of diversity. Still, many questions remain regarding the faculty hiring practices and further

research is required to provide comprehensive recommendations on how to enhance diversity in higher education through equity in faculty hiring.

Appendix

Survey items included in current study[1]

Institutional, advisor, and institutional characteristics

Questions regarding entry-level tenure track faculty positions

How important is each of the following institutional and advisor characteristics to your positive evaluation of an applicant for an entry-level, tenure track faculty position (i.e., tenure track assistant professor) in your department?

Use the dropdown menu to select the level of importance for each item. There are five selection options in each dropdown menu [Extremely Important, Very Important, Moderately Important, Slightly Important, Not at All Important].

- The ranking of the institution at which the applicant completed their postdoctoral appointment
- The ranking of the department at which the applicant completed their postdoctoral appointment
- The research reputation of the applicant's postdoctoral sponsor
- The ranking of the institution from which the applicant earned their doctoral degree
- The ranking of the department from which the applicant earned their doctoral degree
- The research reputation of the applicant's doctoral degree advisor
- The ranking of the institution from which the applicant earned their undergraduate degree
- The ranking of the department from which the applicant earned their undergraduate degree
- The diversity of the institution from which the applicant earned their undergraduate degree.

How important is each of the following applicant characteristics to your positive evaluation of them for an entry-level, tenure track faculty position (i.e., tenure track assistant professor) in your department?

Use the dropdown menu to select the level of importance for each item. There are five selection options in each dropdown menu [Extremely Important, Very Important, Moderately Important, Slightly Important, Not at All Important].

- The applicant has experience as a postdoctoral researcher
- The applicant has teaching experience in their discipline
- The applicant has published articles in reputable journals in their discipline
- The applicant has published articles that challenge norms in their discipline
- The applicant has worked with researchers from disciplines other than their own
- The applicant has worked with researchers from disciplines other than engineering and natural sciences (e.g., policy, sociology, psychology, education)
- The applicant has worked with people of different races and/or ethnicities other than their own
- The applicant has worked with people of different genders than their own
- The applicant identifies as a historically underrepresented racial/ethnic minority (Black/African American, Hispanic/Latinx, Native American/Native Hawaiian/Native Alaskan)
- The applicant identifies as a woman
- The applicant identifies as a person with a disability.

How would you rank the relative importance of each of the following applicant qualifications for an entry-level, tenure track faculty position (i.e., tenure track assistant professor) in your department? Consider 1 as most important and 7 as least important, relative only to the items listed.

Enter one digit (1–7) per text box to rank each item. Values may not be repeated.

- Ability to advise and mentor students
- Ability to contribute to an inclusive climate in the department
- Ability to deliver high quality teaching
- Ability to secure external funding
- Ability to secure external funding to support the inclusion of people from historically underrepresented groups (e.g., women, people with disabilities, historically underrepresented racial and ethnic minorities)
- Ability to implement inclusive teaching strategies (e.g., universal design for learning, culturally relevant pedagogy) in their courses
- Ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs.

[1] Demographic items are not included here.

Questions regarding entry-level non-tenure track faculty positions

How important is each of the following institutional and advisor characteristics to your positive evaluation of an applicant for an entry-level, non-tenure track faculty position (i.e., lecturer, instructor, assistant teaching professor) in your department?

Use the dropdown menu to select the level of importance for each item. There are five selection options in each dropdown menu [Extremely Important, Very Important, Moderately Important, Slightly Important, Not at All Important].

- The ranking of the institution at which the applicant completed their postdoctoral appointment
- The ranking of the department at which the applicant completed their postdoctoral appointment
- The research reputation of the applicant's postdoctoral sponsor
- The ranking of the institution from which the applicant earned their doctoral degree
- The ranking of the department from which the applicant earned their doctoral degree
- The research reputation of the applicant's doctoral degree advisor
- The ranking of the institution from which the applicant earned their undergraduate degree
- The ranking of the department from which the applicant earned their undergraduate degree
- The diversity of the institution from which the applicant earned their undergraduate degree.

How important is each of the following applicant characteristics to your positive evaluation of them for an entry-level, non-tenure track faculty position (i.e., lecturer, instructor, assistant teaching professor) in your department?

Use the dropdown menu to select the level of importance for each item. There are five selection options in each dropdown menu [Extremely Important, Very Important, Moderately Important, Slightly Important, Not at All Important].

- The applicant has experience as a postdoctoral researcher
- The applicant has teaching experience in their discipline
- The applicant has published articles in reputable journals in their discipline
- The applicant has published articles that challenge norms in their discipline
- The applicant has worked with researchers from disciplines other than their own
- The applicant has worked with researchers from disciplines other than engineering and natural sciences (e.g., policy, sociology, psychology, education)
- The applicant has worked with people of different races and/or ethnicities other than their own
- The applicant has worked with people of different genders than their own
- The applicant identifies as a historically underrepresented racial/ethnic minority (Black/African American, Hispanic/Latinx, Native American/Native Hawaiian/Native Alaskan)
- The applicant identifies as a woman
- The applicant identifies as a person with a disability.

How would you rank the relative importance of each of the following applicant qualifications for an entry-level, non-tenure track faculty position (i.e., lecturer, instructor, assistant teaching professor) in your department? Consider 1 as most important and 7 as least important, relative only to the items listed.

Enter one digit (1–7) per text box to rank each item. Values may not be repeated.

- Ability to advise and mentor students
- Ability to contribute to an inclusive climate in the department
- Ability to deliver high quality teaching
- Ability to secure external funding
- Ability to secure external funding to support the inclusion of people from historically underrepresented groups (e.g., women, people with disabilities, historically underrepresented racial and ethnic minorities)
- Ability to implement inclusive teaching strategies (e.g., universal design for learning, culturally relevant pedagogy) in their courses
- Ability to recruit historically underrepresented racial and ethnic minority students into undergraduate and/or graduate programs.

Abbreviations

STEM	Science, technology, engineering, and mathematics
DEI	Diversity, equity, and inclusion
HBCU	Historically Black Colleges and Universities
PWI	Predominantly white institution
MSI	Minority Serving Institution
DES	Data Engineering and Sciences
HSI	Hispanic Serving Institution
REM	Racially and ethnically minoritized
IPEDS	Integrated Postsecondary Education Data System

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40594-023-00431-w.

Additional file 1: Table S1. Descriptive statistics for institutional and advisor characteristics in STEM faculty hiring. **Table S2.** Descriptive statistics for applicant characteristics in STEM faculty hiring. **Table S3.** Descriptive statistics for applicant qualifications in STEM faculty hiring.

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Author contributions
JW analyzed and interpreted the data and completed the majority of the writing for the manuscript. YEP was the principal investigator on the grant funding for this project and is now the principal investigator on the subaward; and thus, was in charge of the design and execution of the study. CMLP is co-principal investigator on the grant and co-led the study design; CMLP also led data collection. SB and YEP contributed to data collection efforts; TC helped with data analysis. All authors contributed to writing and editing this manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
Data will be restricted to the project team's usage for a minimum of two years after the award end date to support potential publishing and other dissemination. Afterwards, investigators will consider requests of internal and external entities to access data, and the requests will be granted on a case-by-case basis. If the request is granted, sharing will be subject to IRB approval and to the execution of a data sharing agreement in which the requester must agree to protections that are at least as stringent as those required by the investigators. All data will be completely de-identified before sharing.

Declarations

Competing interests
The authors declare that they have no competing interests.

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