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ORIGINAL PAPER

Defining Attributes and Metrics of Effective Research Mentoring Relationships

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Abstract Despite evidence of mentoring's importance in training researchers, studies to date have not yet determined which mentoring relationships have the most impact and what specific factors in those mentoring relationships contribute to key outcomes, such as the commitment to and persistence in research career paths for emerging researchers from diverse populations. Efforts to broaden participation and persistence in biomedical research careers require an understanding of why and how mentoring relationships work and their impact, not only to research training but also to promoting career advancement. This paper proposes core attributes of effective mentoring relationships, as supported by the literature and suggested by theoretical models of academic persistence. In addition, both existing and developing metrics for measuring the effectiveness of these attributes within mentoring relationships across diverse groups are presented, as well as preliminary data on these metrics from the authors' work.

Keywords Mentoring · Mentor · Mentee · Persistence · Metrics

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Mentorship Matters

Strong mentorship has been linked to enhanced mentee productivity, self-efficacy, and career satisfaction; it is also an important predictor of the success of researchers in training [1–13]. Students who are mentored report fewer academic non-persistence decisions [14], with positive mentoring being cited as the most important factor in degree attainment [15]. Mentored graduate students and junior faculty are more likely to publish their research than counterparts who are not mentored [16–18]. Those with mentors also express more confidence [5], report experiencing higher career satisfaction [19, 20], and feel greater support for their careers than their peers without mentors [21]. Mentorship positively impacts not only the mentee but also the mentor. Though there is less research about the benefits of being a mentor, increased productivity among research mentees inevitably leads to increased productivity for research mentors [22]. Examples of other benefits to mentors include a sense of fulfillment through knowledge

and skill sharing, sharpening of leadership skills, and increased awareness [13, 22].

For underrepresented racial and ethnic minority (URM) students, mentorship has been shown to enhance recruitment into research-related career pathways [23, 24]. Both virtual and face-to-face mentoring have been shown to increase exposure and retention [25]. At the faculty level, having (or having had) a formally designated mentor was identified as a significant predictor of high research productivity, second only to the faculty member being "internally driven to conduct research" [26]. Other reports show that mentoring in the context of a junior faculty development program can improve retention in academe [27, 28].

Despite the positive impact that mentorship has been shown to have on URM students, studies have reported that URM individuals typically receive less mentoring than their non-minority peers [21, 29–32]. In studies on barriers to NIH funding, URM faculty investigators indicated that inadequate mentoring, lack of understanding about institutional requirements, lack of institutional support, and social, cultural, and environmental factors all posed obstacles to success [32]. While a lack of mentoring is not unique to URM faculty, the effect disproportionately impacts those from URM backgrounds, especially those in majority/white institutions.

Focus on Mentoring Relationships, Not Just Mentors

Mentoring has both overlap with and distinctions from apprenticeship and coaching as touched upon by McGee (p. x, this issue). Mentorship "consists of a reciprocal, dynamic relationship between mentor (or mentoring team) and mentee that promotes the satisfaction and development of both" (McGee, p. x this issue). Mentoring is collaborative; mentees are not passive recipients of a mentor's guidance. Ideally, mentees and mentors engage as partners through reciprocal activities such as planning, acting, reflecting, questioning, and problem-solving. This dynamic relationship changes over time, proceeding through purposeful developmental phases where expectations must be consciously negotiated (see McGee, this issue). Moreover, mentoring is a relationship that occurs within a given social context in which both the mentee and mentor are viewed as "learners," with (1) the mentee acquiring research skills needed for scientific productivity and career-related knowledge essential to advance, (2) the mentor acquiring a working knowledge of the mentee in order to effectively nurture academic and professional growth of the next generation, and (3) the capacity of both to engage and find the "delicate balance between respect for tradition and openness to change" which must be found to advance the field [33, p. xii].

Successful mentoring relationships can be measured by a mentee's success in reaching individual milestones that allow her or him to progress to the next stage along the trajectory for a sustainable career. Further, successful relationships produce mentees with the (1) personal and professional competencies necessary to define their career goals, (2) experience needed for realizing their career goals, and (3) ability and opportunity to progress toward their chosen career goal. Thus, mentor success is defined as having the skills and knowledge to effectively support mentee development by facilitating the attainment of the transferrable skills, knowledge, and confidence (competencies) necessary to meet individual goals. This requires the mentor to come to a clear understanding of each mentee's unique needs and desires and the flexibility and humility to adjust one's approach to support a mentee's success.

While each mentoring relationship is unique, the knowledge and skills needed for the relationship to function effectively can be developed. The notion of bringing mentors and mentees together and assuming that they have the skills and knowledge to build a successful relationship is not only naïve, but favors mentee populations that already possess the social capital to connect with their mentors. Mentoring of emerging scientists and researchers should be inclusive and intentionally guided by what is known in research to affect positive outcomes for trainees from diverse backgrounds. Historically, however, few mentors have been trained in effective mentoring methods and even fewer mentees have been trained in how to guide their mentoring relationships and careers. While some progress has been made (see Gandhi and Johnson, this issue and [34]), standards and metrics are needed to define, align, and guide mentors' and mentees' perceptions and behavior within their relationships in order to achieve the positive benefits of the mentoring relationship [35].

The Need to Study Mentoring Relationships

To address the lack of training and standardization in effective mentoring methods, several federal funding agencies such as the National Institutes of Health have asserted the need for research on mentoring, the results of which can lead to the creation of evidenced-based practices [36]. Despite evidence of mentoring's importance, little is known about the complexities of research mentoring relationships both in terms of how individual cultural difference factors like race, ethnicity, and gender influence these relationships as well as the effectiveness of different forms of mentoring.

Mentoring is a social relationship involving an interpersonal exchange influenced by both the mentee *and* mentor perceptions of the other [37]. And because mentees and mentors have diverse individual attributes [38] and mentoring occurs in a given social context (e.g., a specific institution, a specific discipline), mentoring relationships are culturally informed (Walters, this issue). For instance, some research has found that URM women in science and engineering were significantly more interested than their White counterparts in having discussions with their mentor about issues of race/ethnicity [39]. Byars-Winston et al. [25] found that URM students were more likely than their predominantly White mentors to endorse that cultural diversity matters should be addressed in the research mentoring relationship [37]. Prunuske et al. [40] found that mentors of URM mentees tended to espouse colorblind attitudes and the notion that cultural diversity is irrelevant to the research mentoring relationship [40]. Does it matter to the effectiveness of the mentoring relationship if the mentor and mentee are aligned in their views on addressing cultural diversity issues? How might cultural diversity variables like race, ethnicity, and gender moderate the relationship of mentoring to outcomes? Research [41–44] clearly indicates that cultural diversity variables can complicate the mentoring relationship, but it is unclear how and through what mechanisms they exert their influence on the relationship.

Despite some promising research (see [12, 45]), it still remains unclear which types of research mentoring relationships (e.g., dyads, dual or multi-mentored, peer) and which modes of mentoring (e.g., formal, informal, face to face, online, long-term, short-term) have the greatest impact on mentee success, in which contexts, and at which career stages. Meta-analyses have been published that identified features of effective mentoring such as frequency of contact and longevity and described the benefits of various forms of mentoring [46], but much of this work is based on disciplinary fields outside of the sciences. The extent to which these findings are generalizable to research mentoring relationships must be determined. Likewise, identification of specific factors that account for key academic and career outcomes in the sciences, such as commitment and persistence, are just only recently emerging. However, most of the published studies did not use (or did not report) measures that were valid for individuals in the sciences, particularly for URM individuals, nor were the measures based in theory [47]. In order to examine the complex nature of research mentoring relationships and their impact on desired academic and career outcomes for mentees, theoretically grounded and validated measures are needed to assess the quality and effectiveness of research mentoring relationships and to identify factors that shape a successful research mentoring experience. Bearman et al. [48] asserted, "If studying mentoring is a scientific enterprise, then determining its mechanisms is what allows us to develop mentoring technology" [48]. Investigations into the mechanisms underlying successful research mentoring relationships will allow for the development of systematic mentor and mentee training interventions that incorporate those factors identified as salient in producing their success.

This paper examines several existing conceptual frameworks that can be used to understand mentoring relationships and what may make them effective, particularly in the areas of biomedical and health science research. The main factors relative to effective mentoring in each of the frameworks are discussed, providing an overview of the types of key measures needed to assess effective mentoring relationships. The subsequent knowledge that will come from using the measures within these conceptual frameworks to study what makes mentoring work will serve as a foundation upon which to articulate evidence-based practices for mentoring relationships in the future.

Conceptual Frameworks for Examining Mentoring Relationships

Career paths, including those in science, are determined by a complex interaction of experiences, inclinations, and choices that begin in early childhood. Mentoring is one of the primary vehicles for guiding the progression of nascent scientists along their career paths as they develop the knowledge base, skills, and habits of mind that will inform their decision about whether a career as a scientist aligns with who they are and who they want to become. Because mentoring relationships and the development of career intentions do not happen in random fashion or in a vacuum, theories and conceptual frameworks that delineate factors relevant to effective mentoring should be incorporated into designing interventions to guide highly productive and purposeful relationships. Several theories and models reveal the "mechanisms" by which individuals persist, or not, along the pathways toward becoming a scientist and how they learn skills for successful careers [49, 50]. Theories tend to serve as abstract explanations of phenomena, whereas models tend to illustrate the relationships among different structures and processes. Theories can inform both the construction of and inferences made from testing models. Below we present the model of academic persistence and career attainment and several theories that make important contributions to our understanding of attributes that matter in mentoring relationships. We subsequently focus on measures for assessing attributes of mentoring relationships and describe a national initiative to transfer

what is learned from research into intentional practice that increases the diversity and quality of successful scientists.

Academic Persistence and Career Attainment

During the past 25 years, academic persistence has garnered considerable attention as a model for undergraduate and graduate students [41, 51–53]. This model is theoretically rooted in the psychological literature on person-environment fit [12, 53] and in sociological theory of integration in institutions [50], capturing many factors identified in empirical studies as critical influences on short-term academic outcomes with implications for long-term career attainment outcomes. The model asserts that students enter higher education with a variety of personal attributes (e.g., gender, sexual orientation, culture), pre-college experiences (e.g., academic or social attainments), and family backgrounds (e.g., socioeconomic status, parental education). Each of these characteristics directly or indirectly affects college performance as well as students' perceptions of themselves and their career options. During college, the extent to which students become integrated into academic and social systems affects their commitment to their institution; in turn, this commitment predicts completion of a college degree. Similar models [1, 14, 29] highlight the influence of social support, formal mentoring, institutional environment, cultural congruity, and academic stress on academic persistence. It is important to note, however, that the academic persistence model was to serve as a guide, illustrative of what happens in interventions in college. It has not been empirically tested as a model for subsequent career stages and the complex relationships that depend on mentoring for successful careers.

Although intimated in the academic persistence model, there are other important contextual dynamics that influence an individual's academic persistence and career attainment. For instance, beyond acquiring disciplinary training, successful trainees likely also acquire navigational capital [54] or the tacit "know how" skills for maneuvering through and negotiating political and disciplinary minefields encountered (see Manson, this volume). Moreover, individual integration into a college, a discipline/field of study, or even a profession is not unproblematic. However, it is particularly challenging for high achieving underrepresented groups who face "solo status", stereotyping, or discrimination. These additional hurdles for many URM trainees must be considered in applying academic and career persistence models and theories as lenses through which to view critical elements of mentoring relationships. The details of selected theories are presented below as the basis for a list of proposed attributes and accompanying metrics of effective mentoring relationships.

Social Cognitive Career Theory (SCCT)

SCCT articulates the mechanisms that underlie individuals' motivation, goal setting, and persistence toward a given academic outcome and career path [55], explaining how individuals' beliefs about their own capabilities (self-efficacy) and beliefs about response outcomes (outcome expectations) direct their pursuit of a given task. Briefly, SCCT posits that people are likely to form enduring *interest* in an activity when they view themselves as competent at performing it (self-efficacy) and when they expect the activity to produce valued outcomes (outcome expectations). Along with self-efficacy and outcome expectations, interests foster particular educational and occupational *choice goals* (e.g., intentions to pursue a particular career path), which, in turn, make it more likely that people will take *actions* to achieve their goals (e.g., apply to a graduate degree program or seek entry into a research career). Their subsequent *performance attainments* (e.g., successes, failures) provide valuable feedback that can strengthen or weaken self-efficacy and outcome expectations and ultimately help to revise or stabilize choices.

SCCT recognizes that educational and career choices are also affected by environmental variables, conceptualized as *contextual supports and barriers* (e.g., family support, economic need), that can moderate the effects of personal interests on choices. Importantly, the theory takes into account several pathways though which individual difference factors (e.g., gender, race, personality) affect the academic and career development process. The SCCT model has received considerable empirical support in studies with individuals in science, technology, engineering and mathematic (STEM) fields across gender, racial/ethnic groups, and career stages from undergraduates to early career faculty [56–59]. Research has shown support for science self-efficacy, or confidence in ones' ability to successfully perform scientific work, is an important mediator of research experience on students' commitment to a research career. Notably, research mentoring has a positive effect on self-efficacy for science and research tasks [37, 42].

Science Identity Development and Social Negotiation

Science identity explains how an individual can adopt a professional identity within the scientific culture. It describes how recognition of one's self as a potential scientist *and* others' recognition of them as a potential scientist become their career-related identity, which, importantly, predicts future science-related behavior [52, 60]. Science identity is developed and nurtured by three overlapping dimensions, *competence* (one's own assessment and that of

others), *performance* (skills and opportunities to act like a scientist), and *recognition* (acknowledging oneself and achieving recognition as a scientist by others) [43]. Numerous studies have found that self-efficacy is linked to strong science identity, [10, 27, 61, 62]. Importantly, how science identity is negotiated in conjunction with other salient social identities (e.g. gender, race, class) impacts career goals [41–43, 53, 63, 64].

Research on undergraduates confirm that mentors play a critical role in contributing to the development of science identity by recognizing talent, validating mentees' aspirations, teaching them what to do, and giving them opportunities to take on research tasks consistent with their developing competence [42, 53]. However, in the first year of college, negative racial experiences tend to moderate the positive relationship between persistence in STEM and science identity [41]. In longitudinal models of diverse students, science identity and value internalization are more durable predictors of persistence and integration into a community of scientists than self-efficacy alone [63]. Students in graduate school continue to negotiate their science identity and other social identities within educational and professional contexts, using a variety of strategies [64]. The challenges of stereotyping and social identity do not disappear in later life, but individuals learn how to manage their science and social identities to achieve their career goals. For graduate and postdoctoral mentees, socio-emotional mentoring, self-efficacy, leadership and team self-efficacy, and advanced research experiences influence science identity, which in turn is the strongest predictor of commitment to a science career [53]. Since self-efficacy and science identity intersect with other aspects of one's social identity (race, ethnicity, sexual orientation, socio-economic class, gender, etc.) [27, 56, 62], it is important for mentors to understand this interaction and recognize that mentees' identities are fluid and continually developing as they advance in their training and continue to reassess their competence based on performance opportunities.

Social Capital Perspectives and Career Stage Mentoring

Social and cultural capital theories focus on the social reproduction of inequality, or how the elite maintain their status across generations [65, 66]. Underlying structures such as social networks, which determine who has access to resources and information (social capital) and whose ideas are heard and considered, impact access to opportunities and subsequent career advancement. Social norms within the academy, including how well they are understood by and salient for a given mentee, influence advancement (See Manson, this issue). At later stages of a career, conformity may be the norm among "academic tribes" for determining membership [67] and professional socialization.

Social capital theory suggests that mentors need to help their mentees learn the values of their professions and fields of study (e.g. what is good research), maintain personal and professional integrity, and navigate cultural and political systems [33, 68]. Among URM faculty, ideal mentors work to demonstrate respect for their mentee, to show support for their mentee's vision and research, to invest in their success and understand the challenges faced by mentees who come from underrepresented groups [68]. The characteristics are reflective of dialogic mentoring relationships, where differences are appreciated and contradictions are opportunities for exploration, problem-solving, and changing viewpoints [69]. The ongoing relationship is characterized by the pursuit of openness and equity of voice, which may be particularly important at later career stages or in working with very talented mentees. This model suggests one in which power differentials (e.g. status, gender, race) are diminished. Social exchange frameworks applied to student-faculty mentoring also acknowledge that mentors learn and obtain a variety of benefits from these relationships [70].

While many studies focus on younger students, studies on identity and science career commitments begin to articulate differences at various career stages, testing the indicators that work at different life stages and replicating findings at later stages in a science career [53]. It is essential to target appropriate mentoring at key time points in the development of a career before important choices are made [71]. Because high status occupations and research-related careers depend on networks of individuals and institutional affiliations, life course mentoring "practices geared toward accumulating social capital are critical" [68].

Attributes for Effective Mentoring Relationships

Development of attributes that contribute to the persistence and success of mentees, especially those from URM groups, are needed to support successful research mentoring relationships. The theoretical frameworks described above outline many of these factors, with a particular focus on psychosocial elements, and suggest standards for research mentoring relationships focused on socialization processes that lead to persistence, such as science identity, research self-efficacy, and cultural diversity [12, 37, 41, 42, 52, 53, 62]. It is noted that not every attribute necessarily needs to be addressed in each mentoring relationship but that each factor should be considered as each relationship is assessed for effectiveness.

Table 1 offers a list of attributes, measurable objectives, and assessment metrics for effective mentoring across five

domains: research, interpersonal, psychosocial and career, culturally responsive/diversity, and sponsorship. These are derived from existing literature, proposed organizational frameworks [6, 72], and factors shown to impact academic persistence as described above. The literature from which these attributes were derived is referenced below and in Table 1. Some of these domains overlap with other models of mentoring, broadly defined (including apprenticeship and coaching), described in other articles in this special issue. The attributes are important regardless of the mentoring venue (e.g., face-to-face, virtual), yet it must be acknowledged that the associated metrics may need to be adjusted, or new metrics added, to address the nuances associated with various mentoring contexts. For example, strategies for effective communication when interacting face-to-face differ from those for effective virtual communication, suggesting, for example, that we include attributes and metrics for actively listening online and communicating effectively using email or chat rooms. Finally, we note that cultural competency in mentoring is explored in greater depth in this volume by Dr. Katrina Walters.

Metrics for Assessing Mentors, Mentees and Mentoring Relationships

Currently, there are few metrics available to assess the effectiveness of research mentoring relationships at various career stages. To our knowledge, none of the attributes included in Table 1 have been studied with large pools of diverse mentees, across varied types of research mentoring relationships or across career stages. Definition of attributes and development of metrics are needed to design interventions to support alignment of mentors' and mentees' perceptions of their relationship [35]. Importantly, data from three studies conducted by these authors [24, 37, 73] suggest that mentor–mentee alignment is a critical determinant of effective mentoring relationships. Therefore, the attributes and metrics need to include parallel mentor and mentee measures across research and psychosocial domains, so that alignment may be assessed as an indicator of mentoring effectiveness.

Some metrics for mentors have been developed, such as those reviewed in Meagher et al. [74] and those developed for use in a recent randomized controlled trial of a mentor training intervention [35, 75]. Metrics focusing on mentee gains from mentoring relationships and research experiences include the undergraduate research student self-assessment [76] and the survey of undergraduate research experiences [77]. Studies have also examined the relationship between mentorship and mentees' probability of expressing interest in pursuing a graduate degree in the sciences, whereas others have found that students who leave the sciences tend to find better mentoring and more frequent mentorship that aligns with their interests in other disciplines [78, 79]. Table 1 shows existing metrics that could be used, or adapted, to assess the effectiveness of each proposed standard in a mentoring relationship. Current studies by the authors investigating similar use of additional metrics are described below.

Preliminary Data on New Metrics

Development of metrics to study mentoring relationships is underway. Drs. Byars-Winston, Pfund, and Branchaw are developing survey items for undergraduate mentees that are informed by variables derived from SCCT [47, 55, 57, 80], science identity [53, 63], and cultural competence [73, 81]. In collaboration with the Annual Biomedical Research Conference of Minorities in Science (ABRCMS) leadership and Dr. Christine Pribbenow, these items were included in the annual ABRCMS conference student evaluation in 2012 and 2013 with more than 1000 participant responses. The specific scales within the three areas listed above, and internal reliability estimates (Cronbach's alpha coefficient represented as "α") are summarized in Table 2. Research is currently underway with these metrics to test a hypothesized SCCT model of associations between academic outcomes for undergraduate researchers in the biological sciences and their perceptions of their research mentoring relationships.

Drs. Hurtado and Eagan with colleagues at the Higher Education Research Institute (HERI), have developed a faculty mentorship construct for their College Senior Survey. This new construct resulted from analysis of survey items using item response theory (IRT). Examples of the items in this mentorship measure include the frequency with which students received encouragement to pursue graduate study, advice about their educational program, letters of recommendation, assistance in achieving professional goals, and emotional support and encouragement, among other measures. Data show that STEM students who received more frequent mentorship tended to be significantly more likely to express intentions to pursue graduate degrees in STEM after controlling for other variables, including undergraduate research experiences, financial aid, and interaction with peers [78].

Research using the HERI mentorship construct also has found a negative association between receiving faculty mentorship and student persistence in STEM majors [79]. Rather than indicating that students leave STEM fields after receiving more frequent mentorship from faculty, what this study suggests is that students who leave STEM during college find better and more frequent mentorship in their non-STEM fields that may actually be better aligned

Table 1 Proposed Attributes, Example Objectives and Potential Metrics for Improving and Assessing Mentoring Relationships

Attributes for effective mentoring relationships	Example measurable learning objective *Effective mentors can*	Example measurable learning objective *Effective mentees can*	Existing metrics[a]
Research			
Developing disciplinary research skills	Teach mentees to design and carry out a research project; Provide opportunities to observe techniques	Develop the skills to design and carry out a research project	[73, 76, 82–84]
Teaching and helping to learn disciplinary knowledge	Identify the knowledge mentees need to be successful in the discipline and guide them in learning that knowledge	Seek guidance from their mentors to identify the disciplinary knowledge they need and be receptive to mentor feedback that guides their learning	[73, 83]
Developing technical skills	Provide instruction in core disciplinary research techniques	Commit to learning and gaining proficiency in disciplinary research techniques	[46, 85]
Accurately assessing understanding of disciplinary knowledge and skills	Assess mentee learning of disciplinary knowledge and skills and provide feedback and guidance to address gaps	Self-assess learning of disciplinary knowledge and skills and respond to mentor feedback	[73, 75, 84]
Valuing the practice of ethical behavior and responsible conduct of research	Model the ethical conduct of research and actively engage in conversations with their mentees	Actively familiarize themselves with and follow ethical practices in their research	[33, 46]
Developing mentee research self-efficacy	Foster mentees' internalization of their own research success	Effectively manage anxiety associated with independently conducting research	[55, 56]
Interpersonal			
Listening actively	Give their undivided attention and listen to both their mentees' words and the emotion behind the words	Give their undivided attention and listen to their mentors	[75]
Aligning mentor and mentee expectations	Establish and communicate mutual expectations for the mentoring relationship	Establish and communicate mutual expectations for the mentoring relationship	[73, 75, 84]
Building trusting and honest relationships	Offer honest and open feedback on how the relationship is progressing	Offer honest and open feedback on how the relationship is progressing	[73, 83, 86]
Psychosocial and career			
Providing motivation and facilitating coping efficacy	Scaffold research work in ways that yield periodic success; celebrate the successes and offer support after failures	Acknowledge that research frequently involves setbacks and develop strategies to deal with them	[78, 79]
Developing mentee career self-efficacy	Foster and affirm mentees' career aspirations	Seek opportunities to explore and prepare for a career	[87]
Developing science identity	Recognize mentees as scientists	Affirm themselves as scientists	[44, 53, 76, 78, 79, 82]
Developing a sense of belonging	Create a welcoming and inclusive research environment, especially at transition points	Actively engage and establish relationships with research team members	[88]
Culturally responsive/diversity			
Advancing equity and inclusion	Employ strategies for recognizing and addressing issues of equity and inclusion	Identify strategies for recognizing and addressing issues of equity and inclusion	[37, 73, 75]
Being culturally responsive	Effectively negotiate dialogue across diverse dimensions	Effectively negotiate dialogue across diverse dimensions	[42]
Reducing the impact of bias	Consider their unconscious biases and regularly check that they are not negatively impacting their own or their research team's behavior	Recognize unconscious bias, regularly check that it is not negatively impacting their behavior, and address it when they observe it	[89]
Reducing the impact of stereotype threat	Recognize, acknowledge, and work to reduce stereotypes that may negatively impact their mentees	Recognize stereotypes associated with their group identity and address them to reduce potentially negative impacts	[90–92]
Sponsorship			
Fostering independence	Continuously assess mentees' development and design increasingly challenging tasks and projects to advance mentees' independence	Push themselves to increase responsibility for and ownership of their research, while asking for support and guidance as needed	[73, 75, 84]

Table 1 continued

Attributes for effective mentoring relationships	Example measurable learning objective *Effective mentors can*	Example measurable learning objective *Effective mentees can*	Existing metrics[a]
Promoting professional development	Identify opportunities for mentee professional development and support their engagement in them	Identify and engage in opportunities to develop the professional skills needed to become a successful scientist	[75, 78, 79]
Establishing and fostering mentee professional networks	Introduce and facilitate relationship building between their network of colleagues and their mentees	Actively identify and seek ways to meet and establish relationships with potential future colleagues in the discipline	[79]
Actively advocating	Promote mentees' work; provide professional support	Report successful outcomes to mentor; Seek out and r accept advocacy	[79]

[a] This table includes metrics that have been used to assess the knowledge and skill of mentors and to assess mentoring relationships, as well as metrics that have been used outside the context of studying mentoring relationships but have potential to be adapted for that purpose. The list of metrics is not meant to be exhaustive, but rather to offer starting points for further work

Table 2 Reliability estimates for 3 scales targeting predicted factors of persistence

Item	α
SCCT-related items	
Sources of self-efficacy (four subscales)	0.67–0.85
Research-related self-efficacy	0.91
Research-related outcome expectations	0.78
Research-related career intentions (used as single items)	N/A
I intend to pursue a career in science that includes research	
I intend to pursue a career in science that DOES NOT includes research	
Science identity	0.74
Addressing cultural diversity	
Addressing cultural diversity-importance	0.80
Addressing cultural diversity-skilled	0.88

with their interests. This highlights the need for more and better training of STEM faculty mentors so that they can support mentees to make educated decisions about career paths that align with their personal interests and strengths. In particular, with early career students, who are still exploring their interests, STEM mentors need to be trained to support exploration of these interests to be sure that those who leave STEM are leaving because they found a better fit, not because of lack of effective STEM mentors. This finding also suggests that more research is needed on the strategies of resourceful and resilient students when initial mentoring relationships are not successful.

Next Steps

Research is needed to test the theoretically-based core attributes of mentoring relationships proposed in this chapter. Once established, these attributes, and the profile of their importance in different contexts, can be used to design training interventions that support the development of healthy and productive mentor–mentee relationships. The first step in this process, development of metrics and validated instruments to measure theories that support and these attributes, has begun. Discovery of what matters for the success of mentees from diverse backgrounds, in different contexts, and at different career stages, will require a pool of mentors and mentees to participate in the research. Collaborating with programs such as the National Institute of Health's Diversity Programs Consortium (BUILD/NRMN/CEC; http://commonfund.nih.gov/diversity/Initiatives) and Minority Access to Research Careers (MARC; http://www.nigms.nih.gov/Training/MARC/Pages/USTARAwards.aspx), as well as the National Science Foundation's Research Experiences for Undergraduates (REU; http://www.nsf.gov/crssprgm/reu/) programs will be necessary to recruit large numbers and diverse populations for these studies. The efficacy of mentorship can be studied with attention to whether or not diverse mentees reach key accomplishments in their career or achieve "hallmarks" of success. Currently the NIH Diversity Consortium has identified these outcomes (e.g. entering and completing graduate school, attaining a research or academic position, receiving an R01 grant) as critical along the pathway to successful

research careers. Even before the research however, mentors and mentees can use the attributes proposed here to monitor and advance their existing relationships to establish new relationships that are healthy and productive. These can be applied to relationships of mentors and mentees engaged across the spectrum of HIV research and research paradigms of the day such as treatment and prevention.

Previous qualitative research has established that values, practices and knowledge in various fields and disciplines are transmitted in mentoring relationships [33], and has also identified the qualities of a good mentor and mentoring relationship [68]. We have yet to develop metrics that test identified areas in these studies that occur further along the career stage continuum. Next steps in research should improve the generalizability of many of the qualitative studies at various career stages to establish better metrics of attributes of mentors, successful protégés, and the quality of their relationships. These can then be used to improve the mentoring relationships including those of the diverse researchers who are currently being training and are who are motivated to contribute to the HIV research workforce.

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