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CHATBOTS: A TOOL TO SUPPLEMENT THE FUTURE FACULTY MENTORING OF DOCTORAL ENGINEERING STUDENTS

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ABSTRACT

Aim/Purpose	The purpose of this paper is to explore the efficacy of simulated interactive virtual conversations (chatbots) for mentoring underrepresented minority doctoral engineering students who are considering pursuing a career in the professoriate or in industry.
Background	Chatbots were developed under the National Science Foundation INCLUDES Design and Developments Launch Pilot award (17-4458) and provide career advice with responses from a pre-programmed database populated by renowned emeriti engineering faculty. Chatbots have been engineered to fulfill a myriad of roles, such as undergraduate student advisement, but no research has been found that addresses their use with supplemental future faculty mentoring for doctoral students.

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Methodology	Chatbot efficacy is examined through a phenomenological design with focus groups with underrepresented minority doctoral engineering students. No theoretical or conceptual frameworks exist relative to chatbots designed for future faculty mentoring; therefore, an adaptation and implementation of the conceptual model posited on movie recommendations was utilized to ground this study. The four-stage process of phenomenological data analysis was followed: epoché, horizontalization, imaginative variation, and synthesis.
Contribution	No studies have investigated the utility of chatbots in providing supplemental mentoring to future faculty. This phenomenological study contributes to this area of investigation and provides greater consideration into the unmet mentoring needs of these students, as well as the potential of utilizing chatbots for supplementary mentoring, particularly for those who lack access to high quality mentoring.
Findings	Following the data analysis process, the essence of the findings was, while underrepresented minority doctoral engineering students have ample unmet mentoring needs and overall are satisfied with the user interface and trustworthiness of chatbots, their intent to use them is mixed due to a lack of personalization in this type of supplemental mentoring relationship.
Recommendations for Practitioners	One of the major challenges faced by underrepresented doctoral engineering students is securing quality mentoring relationships that socialize them into the engineering culture and community of practice. While creating opportunities for students and incentivizing faculty to engage in the work of mentoring is needed, we must also consider the ways in which to leverage technology to offer supplemental future faculty mentoring virtually.
Recommendations for Researchers	Additional research on the efficacy of chatbots in providing career-focused mentoring to future faculty is needed, as well as how to enhance the functionality of chatbots to create personal connections and networking opportunities, which are hallmarks of traditional mentoring relationships.
Impact on Society	An understanding of the conceptual pathway that can lead to greater satisfaction with chatbots may serve to expand their use in the realm of mentoring. Scaling virtual faculty mentoring opportunities may be an important breakthrough in meeting mentoring needs across higher education.
Future Research	Future chatbot research must focus on connecting chatbot users with human mentors; standardizing the process for response creation through additional data collection with a cadre of diverse, renowned faculty; engaging subject matter experts to conduct quality verification checks on responses; testing new responses with potential users; and launching the chatbots for a broad array of users.

Keywords	chatbot, supplemental mentoring, engineering, underrepresented minority doctoral students

INTRODUCTION

This research paper explores the potential use of chatbots as a tool to supplement future faculty mentoring of underrepresented minority (URM) doctoral engineering students. Chatbots simulate an interactive conversation with human users through an engineered computer program, such as Twitter. In this case, a mentee asks career advice of chatbots that draw responses from a pre-programmed database populated by renowned emeriti engineering faculty. Chatbots were developed and researched under a National Science Foundation (NSF) INCLUDES (Inclusion across the Nation of

Communities of Learners of Underrepresented Discoverers in Engineering and Science) Design and Developments Launch Pilot award (17-4458) (National Science Foundation [NSF], 2017). Chatbot efficacy is examined through a phenomenological research design (Moustakas, 1994) grounded by an adapted conceptual model posited on movie recommendations, which is referred to as the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. Focus groups with URM doctoral engineering students were utilized to determine whether higher ratings on chatbot satisfaction were a result of positive user interface and perceived trustworthiness, as well as whether satisfaction would drive intent to use this supplementary mentoring option. Chatbots have been engineered to fulfill a myriad of roles, yet no research has been found that addresses their use with future faculty mentoring. The potential efficacy of chatbots is an important area of study, as colleges and universities continue to develop and refine mentoring programs to support career success into and across the professoriate (Buzzannell et al., 2015; Vesilind, 2001; Zellers et al., 2008). Traditional, one-on-one mentoring relationships are often unscalable so virtual faculty mentoring opportunities may be an important breakthrough in meeting mentoring needs across the higher education landscape.

Exploring the effectiveness of chatbots for supplemental future faculty mentoring is of interest in engineering academia due to a growing disproportionality in the number of URMs (particularly African American, Latinx, and Native American) in the professoriate, as only 6% of all engineering faculty identify as such (Roy, 2019). Accordingly, in 2018 approximately 5% of all engineering doctoral students identified as URM, and about 5% of doctoral engineering degrees were awarded to URMs (Roy, 2019). Mentorship for URM graduate students in Science, Technology, Engineering, and Mathematics (STEM) fields can affect the success of their experience and potentially influence interest in and pursuit of a career in academia (Allendoerfer & Yellin, 2011; Green, 2015). However, research has indicated mentorship often is deficient for URM engineering graduate students (Bobick & Biggers, 2018; Chesler et al., 2015; Dixon-Reeves, 2003; Green, 2015; Johnson, 2016). Graduate students in STEM fields benefit primarily from mentoring that provides career information and guidance, networking prospects, and opportunities for joint publications and professional writings (Thomas et al., 2007). In engineering specifically, mentoring from senior faculty can shape one's "engineering thinking" (Chesler et al., 2015, p. 2) and the specific approach by which engineers conceptualize and solve problems. Developing this ability also exposes students to the engineering culture and community of practice through which professionals are united by specific values, identities, knowledge, skills, and epistemologies. Yet, URM graduate students regularly describe feelings of being undervalued and excluded in their doctoral studies, craving mentorship that provides practical and emotional support to successfully navigate academia (Green, 2015). Access to chatbots may address this mentoring shortage by leveraging the tools of automation and digitization to create scalable, universally available virtual mentoring opportunities to supplement traditional mentoring relationships.

LITERATURE REVIEW

Chatbots are used in diverse settings and are becoming increasingly common, both as intervention tools and as the foci of research. They have been employed for a variety of purposes, such as tools for improving health behaviors. In their study, Berry et al. (2005) evaluated the strengths and weaknesses of using different media (i.e., a realistic-character chatbot, a similar-appearing human actor, chatbot voice only, and written text) to persuade students to engage in healthy eating. Consistent with the assumption that a chatbot with expressive emotions, such as facial expressions, is viewed as more credible when its expressions are compatible with its verbal message, Berry et al. also studied how the chatbot's emotional congruence with its message affected believability of the healthy eating message, as compared to an emotionally-inconsistent chatbot. To study these aims, Berry et al. recruited undergraduate students from a university in England, who were randomly assigned to one of the six experimental conditions: realistic-character chatbot with neutral expression, neutral human actor, neutral chatbot voice only, written text, emotionally-consistent chatbot, or emotionally-inconsistent chatbot. The researchers administered pre-tests on healthy eating knowledge and current health behaviors; post-tests on healthy eating attitudes and behaviors and satisfaction with and ease

of understanding of the message; ratings of persuasiveness, trustworthiness, and helpfulness, among other variables; and a memory assessment of the message for health eating.

Berry et al.'s (2005) results demonstrated better ratings of the healthy eating message when it contained a face (either the chatbot or human actor) relative to voice and text only messages. Although the researchers offer no speculation about this finding, it suggests a benefit of presenting informational messages in a way that increases feelings of relatability between the chatbot and user. Further, relative to other media, the chatbot was rated as significantly more likeable and helpful, although message memory was worst with the neutral expression chatbot. Subsequent analyses, however, showed that participants had significantly better message memory when delivered by the emotionally-consistent chatbot compared to the neutral and emotionally-inconsistent chatbots. As it is technologically challenging and more expensive to create chatbots with human-like emotional expressions, this finding suggests an advantage in investing resources to design anthropomorphic chatbots that display faces that are emotionally-consistent with the message content in order to bolster trust (Berry et al., 2005). Despite the positive results from this study, a main limitation is that participants did not interact with the chatbot—rather, it presented a singular message about healthy eating. The researchers acknowledge this limitation and note that the ability to interact with a chatbot may enhance the user experience.

Whereas Berry et al.'s (2005) investigation involved one session between a chatbot and user, Bickmore et al. (2005) conducted a longitudinal study with a chatbot designed to increase physical activity, such as walking, among older adults. Brief interactions with chatbots can be enjoyable and engender trust (Berry et al., 2005), yet it is unknown if this effect dissipates with time. Thus, Bickmore et al.'s study was designed to encourage the development of social-emotional relationships between the chatbot and users through multiple interactions over a 2-month period. Twenty-one older adults were recruited from the Boston Medical Center and randomly assigned to the chatbot condition or standard-care control condition, in which participants received take-home materials about physical activity. All participants completed measures on well-being, loneliness, and health at the start and end of the study. They also logged their daily steps via a pedometer. Chatbot participants completed a semi-structured interview and additional questions at the end of the study regarding chatbot satisfaction, trustworthiness, and friendliness, among other variables.

Bickmore et al.'s (2005) results showed no significant difference between groups on the measure of well-being; however, the chatbot users reported significant reductions in loneliness at the end of the study, hypothesized to be a result of increased socializing from the increased physical activity they experienced. Physical activity, as measured by daily steps, significantly increased over time for the chatbot participants, but not the control group—consistent with the researchers' expectations. Overall, participants in the chatbot condition reported highly positive experiences, indicating they were satisfied with, enjoyed, and trusted the chatbot. Interestingly, a theme emerged from the interviews in which chatbot participants reported feeling initially awkward interacting with the chatbot, but then became more comfortable interacting with it to the point where some participants felt reciprocal care between themselves and the chatbot. Further, participants indicated feeling more motivated to walk as a result of the social bond they formed with the chatbot (Bickmore et al., 2005). The results of this research demonstrate that social-emotional bonds can form between users and chatbots over an extended period of time and that these relationships can be leveraged to motivate healthy behaviors among users. With respect to virtual mentoring relationships, these results show promise for chatbot mentorship and highlight the need for extended use between chatbots and users to develop a meaningful relationship.

In addition to using chatbots to improve healthy eating and physical activity, researchers have employed digital agents for academic advising. de Carolis et al. (2006) developed a chatbot for undergraduate students in order to address barriers related to in-person advisor access, consistency, and student timidity. In response to student questions, the chatbot offered personalized suggestions regarding courses, increasing participation in educational decisions, choosing research topics, and

student life in general. Twenty students were recruited from an Italian university, half of whom used the chatbot and half of whom were instructed to refer to the department website when planning their upcoming academic year. At the conclusion of the study, participants rated the chatbot or website on dimensions of trustworthiness, ease of understanding, likeability, and satisfaction. Results showed that participants rated the website as significantly more trustworthy and easier to understand than the chatbot; however, the chatbot was significantly more likeable and satisfying to interact with. The researchers speculate the chatbot was not rated as more trustworthy or reliable because the students only interacted with it for a short period of time; indeed, others have demonstrated the critical importance of time needed to develop relationships between chatbots and users (Bickmore et al., 2005). Nevertheless, these results demonstrate the utility of using chatbots in academic settings and the preference students have for interacting with a chatbot, in terms of likeability and satisfaction (de Carolis et al., 2006). Moreover, these results offer promise for virtual mentorship via chatbots to address barriers to traditional in-person advice.

Gradually, chatbots have been the topic of investigation for their ability to offer different kinds of guidance. Inspired by the need to offer a resource to students who lack access to a campus pastor, Gosha et al. (2014) developed a chatbot to serve as a spiritual advisor that could provide undergraduate students with an interface in which to discuss questions about their spirituality and spiritual development. In total, 40 students from a historically Black college participated in the study, all of whom interacted with a female chatbot. A majority of participants rated the chatbot as at least somewhat helpful (80%) and its responses satisfying (88%). However, only one-third of participants reported they would use the chatbot again in its current development. Participants noted enjoying the chatbot's concise responses to questions but disliked the lack of availability of other advisors and the chatbot's "robotic voice" (Gosha et al., 2014, p. 127). As this was a pilot study, the researchers provided multiple ways to improve upon the chatbot—such as creating a male chatbot and chatbots with different religious orientations. This suggests tailoring chatbots to the individual user may enhance user experience and maximize the benefit conferred by digitizing this type of advisement.

In a study focused on chatbot mentorship, Gosha (2013) developed a chatbot to mentor undergraduate African American computer science students to address mentoring gaps and provide guidance on graduate school decision-making. The chatbot responses were drawn from interviews with STEM computer science professionals, and participants were randomly assigned to a condition in which they interacted once with a chatbot mentor or a human mentor. Gosha's results revealed the human mentor was more effective in helping participants learn about graduate school and the human mentor felt significantly more supportive than the chatbot. However, participants still rated the chatbot favorably, indicating it appeared competent, had integrity, and provided encouragement. Subsequent interviews with chatbot participants revealed students were interested in supplemental chatbot mentoring, especially as a way to learn about terminology, ask questions they did not know to ask human mentors, and receive non-biased answers to questions about graduate school. Moreover, the researcher noted the chatbot was effective for users of different knowledge levels, ranging from those with little prior knowledge about graduate school to those with extensive exposure.

To evaluate the utility of chatbots in assessing URM student interest in pursuing a career in STEM, Gosha et al. (2018) conducted a study with African American high school students, who listened to a chatbot speak about computer science careers. Afterwards, participants completed a survey about their experience and rated their perceptions of computing careers. Results showed approximately half of the students rated the chatbot as useful and were confident in their ability to work in computer science, and most reported they were somewhat likely to use a chatbot in the future to learn about careers in computing or, more likely, in other fields. Interviews with teachers revealed the students received little exposure to computing careers in their curriculum. Consequently, chatbots were found to be a useful means of addressing gaps in student knowledge about career options in computing and encouraging computing degree pursuits in post-secondary education.

Critical to chatbot relationship success is the ability to enhance user interactions through the creation of a trusting and useful emotional-relational bond (Beale & Creed, 2009; Berry et al., 2005; Bickmore et al., 2005; de Carolis et al., 2006; Lee & Choi, 2017). When users perceive a chatbot to be emotionally relatable, interactions improve, learning is enhanced, more positive attitudes are inspired, and behavioral changes occur (Berry et al., 2005; Bickmore et al., 2005; de Carolis et al., 2006; Gosha, 2013; Gosha et al., 2014, 2018). As noted by Berry et al. (2005), developing an emotionally-consistent chatbot is vital because it likely will be sharing sensitive content with users. Thus, in order for mentees to find a chatbot useful and to feel satisfied with its interface, they must develop trust in its effectiveness as a virtual mentor, which also requires ample time with it (Bickmore et al., 2005). Despite the findings that human mentors are better at forming social-emotional bonds and conveying support and trustworthiness, chatbots have been rated highly across multiple research trials, fare just as well on dimensions of competence, and may even confer certain benefits over human mentors—such as easier accessibility and providing non-judgmental, non-biased responses (de Carolis et al., 2006; Gosha, 2013). Examining the relationship between chatbots and other modalities of communication, such as human interaction, is imperative to study chatbot effectiveness and to draw conclusions about its utility (Nass et al., 2000). Yet, measuring its overall effectiveness may be difficult, as previous studies have utilized different methodologies and measured various emotions and reactions of users (Beale & Creed, 2009; Berry et al., 2005).

Chatbots are helping fill a critical need for support services, ranging from health promotion to spiritual and educational advisement. The results of this body of research highlight the promise of using chatbots to supplement the traditional, human mentoring of URM doctoral engineering students who may benefit from virtual mentorship. However, no research has been found that addresses the use of chatbots for supplemental future faculty mentoring for doctoral students. Mentorship of URM STEM students can significantly impact students' educational success and career trajectories, yet many students lack sufficient mentoring (Allendoerfer & Yellin, 2011; Bobick & Biggers, 2018; Chesler Ruis et al., 2015; Dixon-Reeves, 2003; Green, 2015; Johnson, 2016). Reducing this gap in the literature is imperative to meeting student needs, as successful mentoring provides students with insights on career information and guidance, such as identifying the proper balance of teaching, research, and service; understanding how academia can be complicated by race/ethnicity and gender; networking and publication prospects; and development of the personal qualities that lead to success in the engineering professoriate (Thomas et al., 2007). Clearly, a supplemental means of providing mentorship must be identified to support URM student success.

CONCEPTUAL FRAMEWORK

No theoretical or conceptual frameworks exist relative to chatbots designed for future faculty mentoring; therefore, an adaption and implementation of the conceptual model posited by Lee and Choi (2017) was utilized for this study—which is referred to as the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework (see Figure 1). Frameworks build upon a foundation of established knowledge, offer logical explanations for the relationships observed, and reveal new understandings about a phenomenon (Anfara & Mertz, 2014; Babbie, 2015). In their research on a chatbot that provided movie recommendations, Lee and Choi (2017) discovered those who found the chatbot to be enjoyable, trustworthy, and useful were more likely to feel satisfied and continued to rely on it. The current study intends to demonstrate whether supplemental future faculty mentoring can be accomplished through chatbots and if higher ratings of satisfaction are a result of positive user interface and perceived trustworthiness, which would drive the intent to use it.

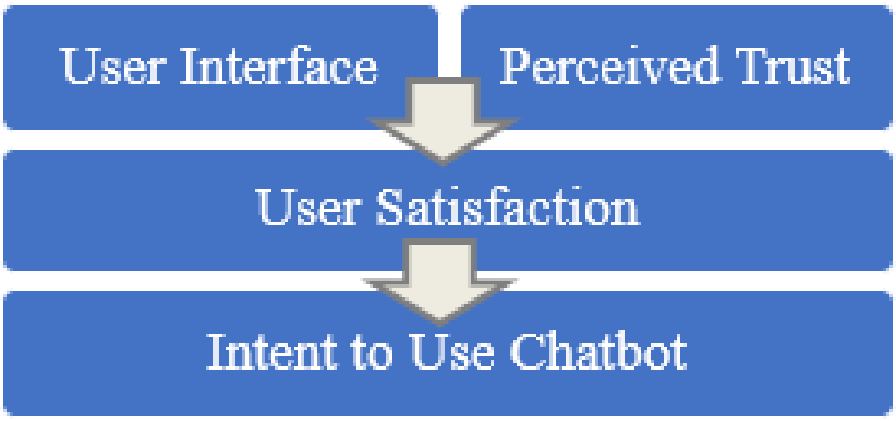

Figure 1. Conceptual Framework for the Efficacy of Chatbots for Future Faculty Mentoring

METHODOLOGY

RESEARCH DESIGN

A phenomenological research design (Moustakas, 1994) was utilized to explore the efficacy of chatbots for supplemental future faculty mentoring through focus groups grounded by the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. According to Creswell and Poth (2017), phenomenological designs allow researchers to capture *what* individuals have experienced and *how* they experienced it by collecting narratives and stories around particular, concrete interactions and events. Thus, phenomenology attempts to study a research participant's "lived experience" (van Manen, 2014, p. 39) with a particular phenomenon and to develop a sense of what any one experience with a phenomenon was like for the individual who underwent it. The goal of this method is to provide transferability of findings, specifically the potential to transfer the specific findings beyond the bounds of the study to individuals in similar situations (Moustakas, 1994). The use of focus groups with URM doctoral engineering students allowed for multiple perspectives on the efficacy of the chatbots. The research questions were as follows:

1. Can supplemental future faculty mentoring be accomplished through chatbots?
2. What are the ways in which users are satisfied with interacting with chatbots for mentoring?
3. What are the ways in which users intend to use a mentoring chatbot in the future?

A flowchart of the research design is provided in Figure 2 with details of each step explained in subsequent sections.

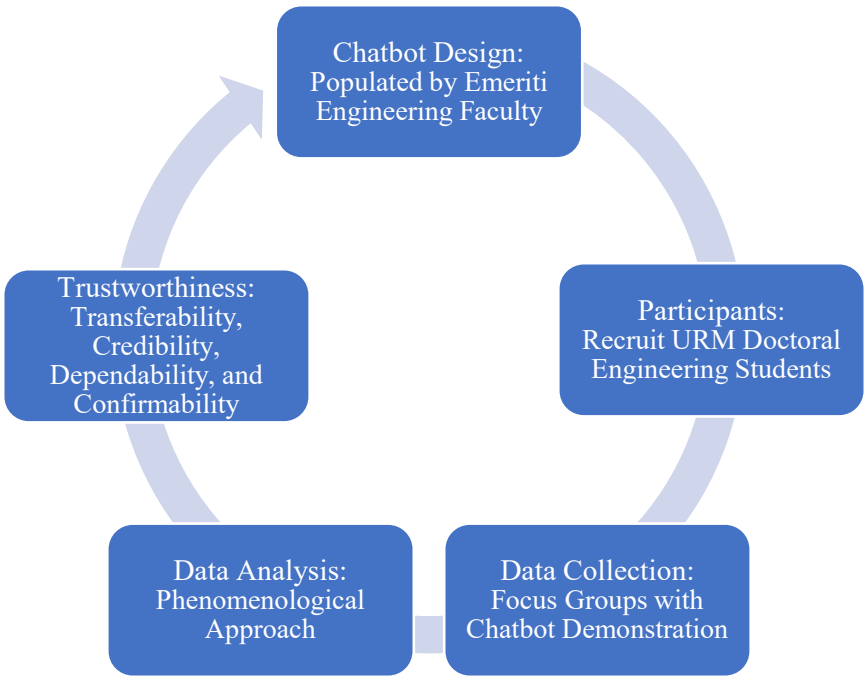

Figure 2. Research Design for Studying the Efficacy of Chatbots for Future Faculty Mentoring

Chatbot Design

The future faculty mentoring chatbots were populated by seven emeriti faculty members selected because of their renowned stature in the field, collective expertise, and continued engagement in academia during retirement. Most maintained sponsored research activities and research labs, some taught undergraduate and graduate engineering courses, and one held an administrative assignment in his Provost's Office. All participants were White, male, and retired from the same doctoral-granting university with very high research activity representing various engineering disciplines such as aerospace, biomedical, chemical, industrial systems, and mechanical. All the emeriti faculty had participated in the Increasing Minority Presence within Academia through Continuous Training (IMPACT) mentoring program, which paired emeriti and URM early- and mid-career engineering faculty for career mentorship. The IMPACT program was sponsored by a NSF Office for Broadening Participation in Engineering award (15-42728 and 15-42524) (NSF, 2015). The development and research of chatbots was sponsored by a NSF INCLUDES Design and Developments Launch Pilot award (17-4458) (NSF, 2017).

The chatbots' responses were drawn from one-on-one interviews with the emeriti faculty; the most representative and concise responses were utilized for content. The chatbots were built in Dialogflow, a chatbot technology framework, and transferred to various interfaces (e.g., Twitter, Google Assistant, text message). The chatbots share the perspectives and insights of the emeriti faculty on the proper balance of teaching, research, and service; what makes for a successful mentoring relationship; and the personal qualities that can lead to success in the engineering professoriate. Refer to Figure 3 for Twitter and text message examples of the chatbots responses. Specifically, the chatbots responded to the following questions:

1. In engineering, is there a proper balance of teaching, research, and service?
2. Is the balance of teaching, research, and service complicated by race/ethnicity or gender?
3. What components are needed in a successful mentoring relationship?
4. Are there personal qualities an individual should possess to be successful in an academic career?

5. Are there personal qualities that inhibit individuals from being successful in an academic career?

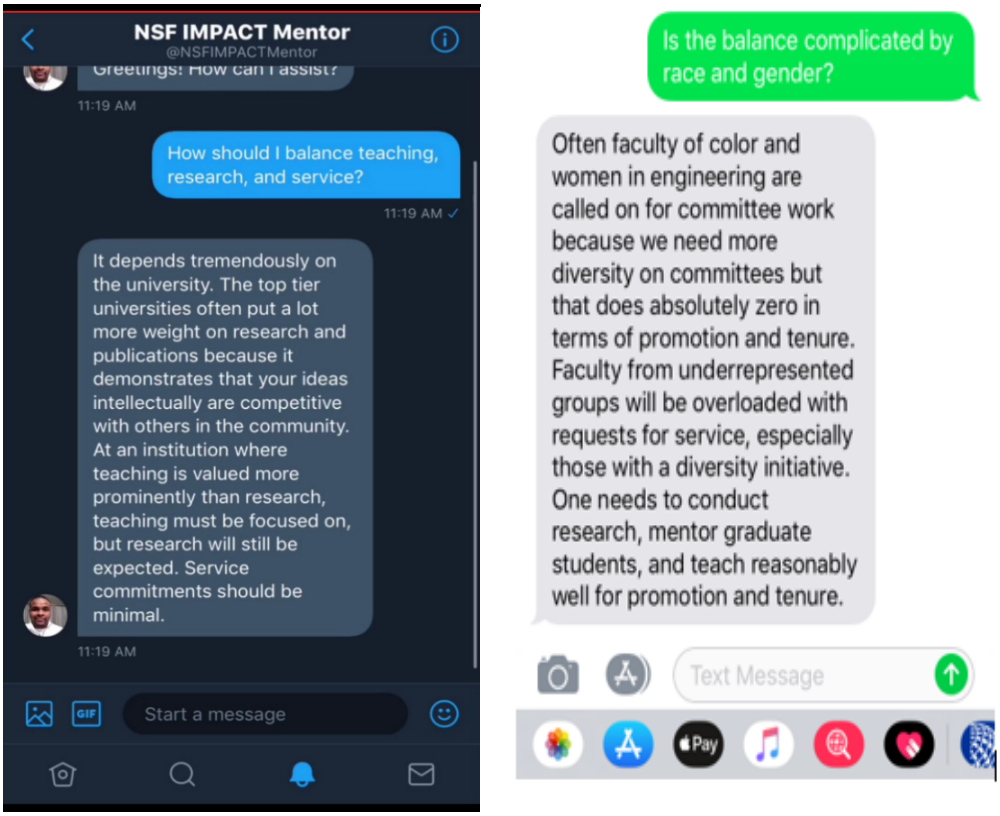

Figure 3. Twitter and Text Message Chatbot Examples

PARTICIPANTS

Upon obtaining Institutional Review Board approval, URM doctoral engineering students at Georgia Institute of Technology and Emory University were contacted to participate in a focus group on the potential efficacy of utilizing chatbots for supplemental future faculty mentoring. Two focus groups, each comprised of five URM doctoral engineering students, were conducted. Seven of the participants were female, all identified as a racial or ethnic minority, and the age of participants ranged from 24 to 33. The variation among participants is displayed in Table 1. Each student was given a $100 Mastercard gift card for participating in a focus group.

Table 1. URM Engineering Doctoral Student Focus Group Participants

Participant Number	Gender	Race/Ethnicity	Age	Engineering Discipline
1	Female	Cuban and Black	33	Industrial
2	Female	Hispanic	28	Interactive Computing
3	Female	Hispanic	27	Biomedical
4	Female	Hispanic	26	Biomedical
5	Female	African American	25	Electrical and Computer
6	Female	Jamaican American	25	Biomedical

Participant Number	Gender	Race/Ethnicity	Age	Engineering Discipline
7	Female	African American	24	Chemical
8	Male	White and Hispanic	26	Mechanical
9	Male	African American	24	Aerospace
10	Male	Mexican and Filipino	24	Biomedical

Data Collection

At the start of each focus group, participants were provided with consent forms detailing the purpose of the study and the focus group procedures, along with a demographic sheet to complete. The focus group began by participants viewing a series of chatbots developed in text message form, Twitter, and Google Assistant to become familiar with the technology and the chatbot content. The focus group protocol was developed from the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework to address the study's research questions. For example, queries were posed on whether individuals were satisfied with the chatbot advice, felt they could trust the information provided, and would recommend it to others. Adherence to the protocol ensured questions were carefully worded and asked in a specific order, probing questions provided opportunities to seek clarification and meaning (Creswell & Poth, 2017). The focus groups averaged 90 minutes in length, were digitally recorded, and were conducted with the same facilitator to ensure data were gathered in a systematic manner (Creswell & Poth, 2017). Upon completion of each focus group, all recordings were transcribed by a third-party transcription service. Once completed, the transcripts were reviewed and cleaned for any errors, and all recordings were permanently deleted.

Data Analysis

The four-stage process of phenomenological data analysis of the focus group transcriptions as outlined by Moustakas (1994) was followed to ensure coding credibility and dependability: epoché, horizontalization, imaginative variation, and synthesis. Phenomenology is used to discover patterns in the data and to develop a rich description of the essence of the phenomenon under study—in this case, the potential efficacy of utilizing chatbots for supplemental future faculty mentoring. In the first stage prior to the focus groups, the researchers engaged in the process of epoché in which experiences, beliefs, values, and assumptions about the phenomenon were bracketed out individually and collectively to allow the data collection and analysis process to be conducted with as little researcher bias and preconceptions as possible (Moustakas, 1994). The researchers are employed at higher education institutions and hold professorship, graduate research assistant, and/or administrative positions on their respective campuses. Each are committed to diversifying the professoriate and have engaged in such efforts through research lines and service endeavors that have advocated for policies and practices aimed at increasing the representation and success of URM faculty within their fields of study. All participated in formal and informal mentoring programs and believe these relationships played an integral role in their careers. Following the advice of Giorgi (2006), bracketing occurred through all phases of data collection and analysis rather than as a one-time occurrence in order to mitigate researcher bias through analytical memoing in which thoughts, ideas, and initial emerging patterns were noted.

In the second stage, inductive, open coding of significant statements was conducted by horizontalization in which transcripts were read with equal value (Moustakas, 1994). The statements were reduced to those that were non-repetitive and parsimonious and then clustered into initial patterns by combining like significant statements using in vivo codes—the participants' own words. The initial patterns represented the ways in which the focus group participants articulated their initial impressions of the chatbots and their potential use in supplementary future faculty mentoring. The Efficacy of

Chatbots for Future Faculty Mentoring conceptual framework was used as a deductive lens with which to consider a variety of meanings that informed the initial inductive patterns. The inductive and deductive patterns were synthesized to provide unique textural descriptions for each participant and then amalgamated to create a universal textural description of the phenomenon (Moustakas, 1994).

In the third stage through the process of imaginative variation, the underlying structure of the phenomenon was explicated by addressing the contextual factors and conditions that determined the participants' perceived efficacy of the chatbots for mentoring (Moustakas, 1994). Specifically, the participants' impression of the user interface, trustworthiness of the responses, overall satisfaction of the chatbots, and their intent to use the chatbots in the future were explored. This process is considered an analytical, mental experiment where varying perspectives can be examined (Moustakas, 1994). As with the textural descriptions, individual structural descriptions were first developed and then synthesized to create a composite structural description that attempted to elucidate the meaning underlying the phenomenon.

In the final and fourth stage, the textural and structural descriptions of the phenomenon were synthesized to develop the essence of the phenomenon (Moustakas, 1994). The essence is not to be considered comprehensive or exhaustive since participants' perceptions are situated within their unique contexts and circumstances and by their particular vantage point. At this stage, three invariant qualities/themes emerged: (1) unmet mentoring needs of URM doctoral engineering students, (2) overall satisfaction with chatbots, and (3) intent to use chatbots is mixed. These themes factored into the essence of the phenomenon which held that, while URM doctoral engineering students have ample unmet mentoring needs and overall are satisfied with the user interface and trustworthiness of the chatbots, their intent to use them is mixed due to a lack of personalization in this type of supplemental mentoring relationship.

Trustworthiness

Multiple verification strategies ensured the findings were trustworthy (Lincoln & Guba, 1985). To ensure transferability, thick, rich descriptions were employed by utilizing direct quotes from the URM engineering doctoral student participants in the findings (Patton, 2015). Credibility was attained through triangulation of the focus groups when unique textural and structural descriptions were synthesized into universal descriptions in the phenomenological data anaysis process (Moustakas, 1994; Patton, 2015). Dependability was addressed by evaluating the manner in which the invariant qualities/themes and essence of the phenomenon represented the whole of the focus group transcripts (Moustakas, 1994). Additionally, engaging in the epoché process through bracketing during data collection and analysis bolstered the dependability of the findings. Researchers ensured confirmability by validating themes in the early and late stages of the data analysis process (Miles et al., 2013) and by culminating the data analysis process with developing the essence of the phenomenon (Moustakas, 1994). Dependability and confirmability also were accomplished by involving multiple researchers in evaluating and providing feedback in the data analysis process, which enabled the comparison of several feedback loops. Application of these verification methods were employed to mediate the limitations of this study (Lincoln & Guba, 1985; Miles et al., 2013).

FINDINGS

Following Moustakas' (1994) phenomenological data analysis process of epoché, horizontalization, imaginative variation, and synthesis, three invariant qualities/themes emerged. These invariant qualities/themes factored into the essence of the phenomenon: while URM doctoral engineering students have ample unmet mentoring needs and overall are satisfied with the user interface and trustworthiness of the chatbots, their intent to use them is mixed due to a lack of personalization in this type of supplemental mentoring relationship. The invariant qualities/themes are explicated below.

Unmet Mentoring Needs of URM Doctoral Engineering Students

The URM engineering doctoral students shared a multitude of mentoring needs, but only some were being met. It appeared their needs hinged on finding a balance between their current work as students and their future work as faculty, as well as understanding the important milestones to be accomplished before graduation. One noted she would benefit from mentoring on the "academic process, how to manage the professional world and academic world . . . producing papers for conferences versus making yourself an asset to a company for an internship . . . balancing that tight line is difficult." All participants indicated they had no formal mentor in academia, although some noted their advisor fulfilled some of their needs. Most described the exceptional and structured mentorship they received during internships. As expressed by one student:

> In industry you are an apprentice to some practice and so someone takes you under their wing but in academia, there's this sense of, "Yeah, you'll get mentored but it's more like you'll get aid from the existing body of work."

The hands-on mentoring that was expected and desired by students appeared to fall short of their needs in academia, while their industry partnerships provided the strategic advice and coaching that promoted their technical and personal growth.

Participants also shared they tended to rely on a constellation of mentors who were acquired informally to ensure their mentoring needs were met. Many noted they took the initiative to reach out to faculty who influenced their work and then leveraged those relationships to receive the mentorship they sought. One shared, "So depending on what I need I'll ask different people at different times, sometimes for a specific decision I'll ask for multiple perspectives from several people but not from one person and definitely not in a formalized way." Most students agreed the lack of formal mentoring in academia was disappointing yet understandable, as they believed mentoring should occur "organically" rather than through assignment. One indicated she sought out her mentors for two reasons: "to understand their path and ways to learn from their experiences and to have someone help me through a decision or moment of uncertainty." Another mentioned she would benefit from a mentor being assigned to her because "if you don't know what you need then it's hard to know what to ask." As each participant identified as URM, they found it challenging to locate a mentor who shared similar racial and cultural backgrounds. The women described this need as critical to their personal and professional development, as well as their career trajectory.

Overall Satisfaction with Chatbots

Satisfaction with the chatbots was driven by positive user interface and perceived trust of the emeriti faculty responses as enunciated in the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. Participants shared that the interfaces of Twitter, text, and Google Assistant ensured easy access and use. While collectively they indicated the response length was appropriate, they also found themselves wanting additional information on what was shared, a few noted a link at the end of the response "for more information" would be valuable, and others added that a story or anecdote would be desirable. Two students mentioned the importance of ensuring the chatbots can meet the needs of those with auditory or visual impairments, or individuals who may have a reading disability, to ensure a broad audience could benefit from this tool. Additionally, a few believed expanding the content to other interfaces would be helpful, such as Slack, a collaboration hub used in academic engineering labs that allows for communication by voice and text, that integrates with various apps and services. One individual inquired whether the chatbots would include a notification system so users could receive information they may not know to ask. She indicated "a notification may be of use or value because they could be providing nuggets of information that you probably would not have thought of, like tips for academic job searching." Another stated the addition of a networking feature

would be useful, as she expressed a desire for the chatbots to connect individuals with similar technical expertise and/or shared cultural backgrounds.

Participants overwhelmingly believed the emeriti faculty responses were credible and useful. One shared: "The answers from the chatbot are from actual emeriti faculty so people who have gone through the process of success in academia . . . and they are top notch in the field." Another specified she had not considered the idea that women and faculty of color often engage in more service requests than their counterparts, as described in one of the chatbot responses. She noted the knowledge of that "extra demand" was enlightening, and she was unsure where she would have found that information on her own. Two students' immediate reaction to the chatbots demonstration involved questions on the uniqueness of the responses, as they felt this advice could be accessed through a Google search or blog. One individual responded that the "beauty of the chatbot was that the responses were vetted and from emeriti faculty who had wisdom to share rather than needing to filter through endless information that would be found on the internet."

Intent to Use Chatbots Is Mixed

While overall the URM doctoral engineering students shared a general satisfaction with the chatbots, they expressed concern on the lack of personalization and relationship building that could occur with the chatbots, which resulted in mixed responses on the intent to use. One participant shared: "What I get from a mentor is the personal connection, personal relationship which helps them identify opportunities that are right for me." Another student followed up on that sentiment: "I don't know that you can develop a relationship with a chatbot that doesn't carry information about you with it . . . it's more of a link to advice." Some questioned the design of the chatbots related to drawing information from several emeriti faculty and suggested a preference for unique chatbots that provided mentoring advice from a particular emeriti faculty member, such as a Native American chemical engineering emeriti faculty member. One noted:

> The potential with this type of technology that would benefit me and add value is if it had a lot of data from professors everywhere in the U.S. of all different demographics . . . And if it was used for data-driven purposes like, "Okay 75% of professors who are women, and Hispanic, have stated X." I think that would be super valuable for me because you could not get that kind of advice from one person.

The importance of contextualizing, personalizing, and identifying the mentor from whom the advice came appeared to be a top priority for all students, as well as the ways in which chatbots could be leveraged to create human connections and networking opportunities.

Participants also saw tremendous value for certain doctoral students having access to this supplementary mentoring tool, mainly those who receive no mentoring or insufficient mentoring, and individuals too shy to ask questions. They shared that students at times are fearful of asking questions that may make them appear naïve to a mentor or advisor, so the anonymity of asking questions of a chatbot was attractive. One said she would recommend chatbots to "people who struggle with actually going out and interacting with people and asking questions because a chatbot would benefit them." Participants also shared they would utilize chatbots if searching for timely information or "quick answers," such as finding a faculty job posting site, professional conferences they should attend, or properly citing an industry internship on their curriculum vitae.

Another individual stated chatbots could be beneficial for those who feel isolated, perhaps who are experiencing conflicts with their advisor or fellow graduate students; she viewed chatbots as an opportunity to provide supportive advice for countless graduate students. Multiple participants expressed that beginning doctoral students, versus graduating doctoral students, may benefit more from interacting with chatbots. According to one participant:

> I just feel mentoring is so specific, and so much of it is so personal, right? I do think it's super helpful for just kind of general basic questions at the start of a doctoral program, but when you have really specific questions to you as a person, it may be more difficult. So I think that would be more for a first or second year.

Equally, they argued that students further in their doctoral pursuits oftentimes have distinct mentoring needs that require thoughtful, nuanced responses that may be better generated by a human mentor with the capacity to tailor advice to the individual—particularly with questions or advice related to issues of diversity. As one student commented, "I'd probably go find… a person to talk to about [race and diversity] because it's a little sensitive and I want a personal response." Overall, participants perceived the chatbots to have great potential as a supplement to traditional mentoring—especially for students who receive insufficient mentoring, shy students, and those in early developmental stages of their graduate education.

DISCUSSION

The present study utilized a phenomenological research design (Moustakas, 1994) to explore the efficacy of chatbots for supplemental future faculty mentoring through focus groups grounded by the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. The essence of the phenomenon held that while URM doctoral engineering students have ample unmet mentoring needs and overall were satisfied with the user interface and trustworthiness of the chatbots, their intent to use them was mixed due to the lack of personalization in this type of supplemental mentoring relationship. The research questions guiding the study were:

1. Can supplemental future faculty mentoring be accomplished through chatbots?
2. What are the ways in which users are satisfied with interacting with chatbots for mentoring?
3. What are the ways in which users intend to use a mentoring chatbot in the future?

The participants indicated supplemental faculty mentoring can be accomplished through chatbots as they believed the perspectives and insights provided by the emeriti engineering faculty through the chatbots would aid them in charting their budding careers, particularly for those considering pursuing a career in the professoriate. In unison, the URM doctoral engineering students shared a multitude of their mentoring needs were unmet, particularly with the milestones they should be accomplishing, such as securing a postdoctoral fellowship before entering the faculty job market. Thus, it is clear there is a mentoring gap that must be filled. This can occur through leveraging technology, like with chatbots, which can supplement traditional mentoring relationships. But it is also evident from the student responses that academia must formally incentivize faculty and others with wisdom to share on the academic career cycle to engage in traditional mentoring. The deficiency in mentoring experienced by the URM doctoral engineering students is not novel information as many researchers have found that this specific population finds it difficult to secure mentoring relationships that socialize them into the engineering community of practice where they are offered career guidance, networking prospects, and scholarship opportunities (Bobick & Biggers, 2018; Chesler et al., 2015; Dixon-Reeves, 2003; Green, 2015; Johnson, 2016; Thomas et al., 2007). The participants who described successful mentoring relationships personally sought them out and attributed additional significance to those who shared their interests and goals, as well as those who enhanced their technical, engineering skills. The women, in particular, desired a mentor who possessed a similar cultural background, affording the opportunity to relate on a personal, deeper level, which is an important consideration to bear in mind.

The focus groups revealed multiple ways in which the URM doctoral engineering students were satisfied with interacting with chatbots for mentoring. The conceptual framework for the Efficacy of Chatbots for Future Faculty Mentoring was useful in interpreting the ways in which the students assigned value to the chatbots and the emeriti faculty responses. Their satisfaction with the chatbots was aligned with positive user interface and perceived trust of the content; the myriad of interface

tools resulted in ease of use, but a need was noted for chatbots to be accessible to a variety of users, particularly those with disabilities. Participants also believed the emeriti faculty responses were credible and useful, and particularly beneficial for those who lacked mentoring relationships, were too shy to ask questions, or were seeking quick, reliable information consistent with the needs of a beginning doctoral student. These latter findings reflect those of Gosha (2013), who found that students were interested in using chatbots to learn about terminology and concepts and ask questions they did not know to ask a human mentor.

The participants also disclosed factors that affected their intent to use mentoring chatbots in the future. Despite the URM doctoral engineering students' positive feedback, the lack of personalization of the chatbot in this study impeded intent to use the chatbots, thus the conceptual pathway of the Efficacy of Chatbots for Future Faculty Mentoring needs to be altered to include an element of "emotional-relatedness" to drive intent to use chatbots. These findings have important implications for the future of virtual mentoring relationships as the doctoral students desired the chatbots to mirror the complex interactions that occur during in-person mentoring, such as free-flowing dialogue and the strengthening of the social-emotional bond over time. This theme has been noted in previous literature. For example, participants in Berry et al.'s (2005) study were unable to spontaneously interact with the chatbot and simply viewed a message about healthy eating. Had they been able to interact with the chatbot freely, the researchers speculated the users may have enjoyed an enhanced user experience. Indeed, permitting users the opportunity to interact in a natural manner with a chatbot and refer to past user questions may allow for more personalized responses in future interactions (Bickmore et al., 2005). Moreover, interacting with a chatbot over an extended period can encourage the development of deeper social-emotional bonds that result in feelings of relatability and care between the user and chatbot, as demonstrated by Bickmore et al. (2005). Further, they expressed concern about the lack of personalization and relationship building that could develop between them and the chatbot, resulting in mixed responses on intent to use a mentoring chatbot in the future. Researchers have documented the need for sufficient passage of time to foster social-emotional bonds and meaningful relationships between users and chatbots, particularly as it allows the chatbot to gather information about the user and tailor responses accordingly (Bickmore et al., 2005).

Another means of enhancing personalization and emotional relatability between virtual mentors and mentees involves personalizing the chatbot itself. In their pilot trial, Bickmore et al. (2005) provided participants the opportunity to select from different chatbot characters of various ages, ethnicities, and body types. Due to budget constraints, however, Bickmore et al. used a racially ambiguous chatbot character in their study. Nevertheless, the ability to tailor chatbots to the individual user may help meet students' needs to relate on a deeper level to the chatbot and its advice and maximize the benefit of virtual advisement (Gosha et al., 2014). Indeed, just the presence of a face, relative to voice or text only, results in better user ratings, suggesting increased feelings of relatability between user and chatbot (Berry et al., 2005). Investing resources in a chatbot that has a human face and, moreover, displays emotions consistent with the content of its message may foster greater trust in the chatbot, creating a dynamic more comparable to that of human interaction (Berry et al., 2005), which may increase users intent to use a mentoring chatbot in the future.

Limitations

As with other studies exploring the utility of chatbots to provide support services to human users, this study has limitations. To begin, only URM doctoral engineering students who self-selected to participate in the focus groups and self-reported their views and experiences were included in this study, which limits the generalizability of these findings (Creswell & Poth, 2017; Lincoln & Guba, 1985; Miles et al., 2019). This factor also speaks to self-selection bias, as those who desired to participate in the study may have been substantively different from individuals who chose not to participate. For example, none of the partificants were extremely satisfied with the mentoring their received in their doctoral programs so they may have been more open to exploring virtual mentoring

opportunities and they chose to participate in the study. And while the focus groups offered insightful views on the utility of chatbots serving as a supplemental mentoring tool, the focus groups could not capture the entirety or complexity of the perceptions surrounding this topic. Moreover, students from top research universities in the Atlanta, Georgia area were recruited to participate so the findings may not be broadly representative of the experiences of URM doctoral engineering students in other contexts.

Additionally, the chatbots designed for this study were created to respond to text and voice inquiries via text message, Twitter, and Google Assistant, and thus lacked the sophistication of visually-based chatbots with faces or full characters capable of communicating with the user via voice and body language. Previous research suggests the presence of a face enhances the user experience and contributes to greater feelings of relatability between the user and chatbot (Berry et al., 2005). In a related manner, participants in the present study were unable to interact with the chatbot spontaneously nor did they interact with the chatbot over time, which could have fostered social-emotional bonds and meaningful relationships between the users and chatbots. Rather, they viewed chatbot responses to pre-determined questions and rated their satisfaction with the chatbot advice, trust in the information provided, and likelihood of recommending it to others. These limitations of the design may have affected students' ratings of the chatbot, including intent to use in the future, and precluded deeper understanding of the full potential benefits chatbots can offer in supplemental mentoring.

Another limitation of the present study concerns the advice relayed by the chatbots. Chatbot responses were populated from one-on-one interviews with emeriti faculty, all of whom were White men. Although participants perceived the information as highly credible and useful, their responses failed to capture the variety and intricacy that may have been offered from a more demographically diverse pool of emeriti faculty with different experiences and advice on advancing through the professoriate or entering a career in industry. As noted by some of the URM doctoral engineering students, this limited the extent to which users related to the advice or felt connected to the chatbots. Indeed, researchers have documented profound benefits of having a mentor of color—particularly to help future faculty navigate complex political climates and relate to mentees from a place of mutual understanding of the impact of race on career advancement and success (Zambrana et al., 2015). Nevertheless, the students rated the chatbots' advice positively and did not express negative sentiments of receiving information from a demographically homogeneous faculty set but future research should focus on how matching demographic characteristics (e.g., gender and race/ethnicity) of users to chatbots affects satisfaction with the chatbot's advice, trust in the information provided, and likelihood of recommending it to others.

Implications

This study demonstrates that chatbots may be effectively employed in the role of mentoring for URM doctoral engineering students when the important elements of positive user interface and perceived trust are included, as others have. For example, the undergraduate participants in Gosha's (2013) study rated the chatbot favorably and perceived its responses as competent, which appeared to influence their likelihood of using a chatbot again for advice on graduate school decisions. Yet, the cornerstone for true success of a chatbot mentor, as measured by intent to use it, requires more sophisticated chatbots. In its current state, it seems students perceive chatbots as a better fit for new doctoral students with more general questions and a smaller need for personalized advice and guidance, suggesting future chatbots should be tailored to a student's developmental stage in order to meet their mentoring needs. It is clear students desire mentorship, even supplemental mentorship, customized to their knowledge, skills, and dispositions and delivered by mentors with whom they can personally identify. The literature notes the importance of the user's ability to develop an emotional-relational bond with chatbots as occurred between participants and the chatbot in Bickmore et al.'s (2005) study, which also is confirmed here. Students stated additional value could be ascribed to chatbots that connect users with human mentors in order to expand their mentoring networks, as well as

chatbots that could generate proactive and personalized advice for users. Thus, further chatbot development requires standardizing the process for response creation through additional data collection with a cadre of diverse, renowned faculty; engaging subject matter experts to conduct quality verification checks on responses; and testing new responses with potential users while ensuring chatbot personalization is a key quality indicator.

CONCLUSION

No research has been found that addresses the use of chatbots in supplementing future faculty mentoring of URM doctoral engineering students. This phenomenological study reduces this gap in the literature through focus groups with URM doctoral engineering students. It calls attention to the necessity to provide greater consideration into the ways in which to address the unmet mentoring needs of these students, as well as the potential for utilizing chatbots for supplementary mentoring—particularly for those who lack access to high quality mentoring. An understanding of the conceptual pathway that can lead to greater satisfaction and ultimately drive intent for using chatbots for mentoring hinges on researchers developing chatbots that can create emotional-relational bonding, not just positive user interface and perceived trustworthiness as initially conceived in the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. Enhancing the personalization and emotional-relational bonding capacity of chatbots may be the key to the future of scaling virtual mentoring in an increasingly automated and digitized higher education landscape.

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