The Use of Chatbots in Future Faculty Mentoring: A Case of the Engineering Professoriate

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Abstract

This research paper explores the potential use of chatbots (simulated interactive virtual conversations) in future faculty mentoring. In this case, a mentee asks career advice of a chatbot that draws responses from a pre-programmed database populated by renowned emeriti engineering faculty. Chatbots are being developed under the National Science Foundation INCLUDES Design and Developments Launch Pilot award (17-4458). Their efficacy for future faculty mentoring is explored through a phenomenological design grounded by the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework utilizing focus groups with underrepresented minority (URM) doctoral engineering students. Chatbots were found to be effective as a supplementary mentoring option as URM doctoral students have ample unmet mentoring needs. Yet, intent to use this type of mentoring was mixed, despite high satisfaction ratings on positive user interface and perceived trustworthiness, because of the lack of personalization in this type of mentoring relationship. The preferred presentation method for this research paper is a traditional lecture, although a demonstration of the chatbot will be provided to afford session participants the opportunity to view and offer feedback on its perceived utility.

Introduction

This research paper explores the potential use of chatbots in future faculty mentoring. Chatbots simulate an interactive conversation with human users through an engineered computer program, such as Twitter or Google Assistant. A mentee asks career advice of a chatbot that draws responses from a pre-programmed database populated by renowned emeriti engineering faculty. Chatbots are being developed 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). Chatbot efficacy is examined through a phenomenological design (Moustakas, 1994) grounded by the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. Focus groups with underrepresented minority (URM) doctoral engineering students were utilized to determine whether higher ratings on chatbot satisfaction was 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 or faculty mentoring. Their potential efficacy for this purpose 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, Long, Anderson, Kokini, & Batra, 2015; Vesilind, 2001; Zellers, Howard, & Barcic, 2008).

Exploring the effectiveness of chatbots in future faculty mentoring is of interest in engineering academia due to a growing disproportionality in the number of underrepresented minorities (URM; particularly African American, Latinx, and Native American) in the professoriate, as only 6.3% of all engineering faculty identify as such (National Action Council for Minorities in Engineering, 2014). Accordingly, in 2016 nearly 5% of all engineering doctoral students identified as URM, and about 10% of doctoral engineering degrees were awarded to URMs (Yoder, 2018). Mentorship for URM graduate students in Science, Technology, Engineering, and Mathematics (STEM) fields can affect the success of their experience and potentially influence their 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, Willis, & Davis, 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 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 interventions for healthy eating (Berry, Butler, & de Rosis, 2005) and exercise (Bickmore, Caruso, Clough-Gorr, & Heeren, 2005), as well as to provide academic advising (de Carolis, Pizzutilo, Cozzolongo, Drozda, & Muci, 2006) and counseling services (Marsella, Johnson, & LaBore, 2003). However, considerably less research has investigated their use for mentorship, although they have become an important topic of study. Gosha, Porter, Cherry, Ordu, and Horace (2014) developed a chatbot to serve as a "spiritual advisor" that could provide African American STEM students with an interface in which to discuss questions about their spirituality and spiritual development. Reactions to the chatbot revealed most were satisfied with the responses and found it to be helpful and easy to use.

Gosha (2013) developed and studied a chatbot to mentor undergraduate African American computer science students to address mentoring gaps and to 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 conditions in which single-interaction chatbot effectiveness was compared with traditional in-person mentoring. Gosha's (2013) results revealed a significant difference between a chatbot and a human mentor in only psychosocial support; the human mentor was rated higher in supportive mentoring. More recently, Gosha, Huff, and Scott (2018) recruited African American high school students for a study on careers in computing. Participants listened to a talk by an online chatbot about computer science careers, after which they completed a survey about their experience. Results demonstrated nearly half of the students rated the website as useful and were confident in their ability to work in computer science, and most reported intent to use a chatbot in the future.

Studies have shown chatbots may be effectively employed in the pedagogical role of mentoring (Berry et al., 2005; Bickmore et al., 2005; de Carolis et al., 2006; Gosha, 2013; Gosha et al., 2014; Gosha et al., 2018; Marsella et al., 2003). Critical to chatbot relationship success, though, 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. As noted by Berry et al. (2005), developing an emotional congruent chatbot is vital because it likely will be sharing sensitive content with mentees. 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 digital mentor, which requires ample time with it (Bickmore et al., 2005). 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, Isbister, & Lee, 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).

Conceptual Framework

No theoretical or conceptual frameworks exist relative to chatbots designed for future faculty or faculty mentoring; therefore, an adaption and implementation of the conceptual model posited by Lee and Choi (2017) was utilized for this study—the Efficacy of Chatbots for Future Faculty Mentoring (see Figure 1). 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 continue to rely on it. The current study intends to determine whether future faculty mentoring can be accomplished through chatbots and whether higher ratings of satisfaction are a result of positive user interface and perceived trustworthiness, which would drive the intent to use it. According to Lee and Choi (2017), trust in technology is developed when it successfully fulfills a human request and the individual has confidence the chatbot can perform well.

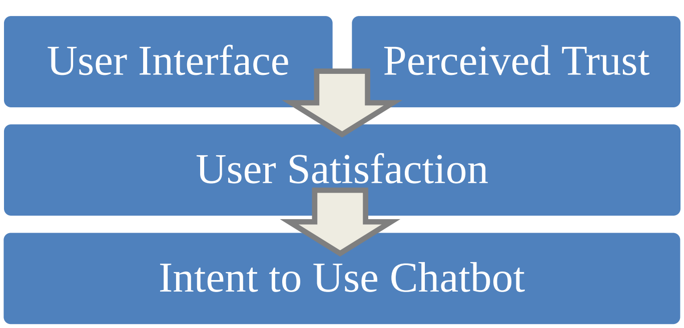

Figure 1. Conceptual Framework for the Efficacy of Chatbots for Future Faculty Mentoring. Adapted from “Enhancing User Experience with Conversational Agent for Movie Recommendation: Effects of Self-Disclosure and Reciprocity,” by S. Y. Lee and J. Choi, 2017, *International Journal of Human-Computer Studies, 103*, p. 97.

Methodology

Research Design. A phenomenological research design (Moustakas, 1994) was utilized to explore the efficacy of chatbots in 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 explore *what* individuals have experienced and *how* they experienced 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 (Creswell & Poth, 2017). The use of focus groups with URM doctoral engineering students allowed for multiple perspectives on chatbot efficacy. The research questions were as follows:

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

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 of 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 is sponsored by a NSF INCLUDES Design and Developments Launch Pilot award (17-4458).

Chatbot responses were drawn from one-on-one interviews with the emeriti faculty; the most representative and concise responses were utlized for the chatbot 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 2 for Twitter and text message examples of the chatbot 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?

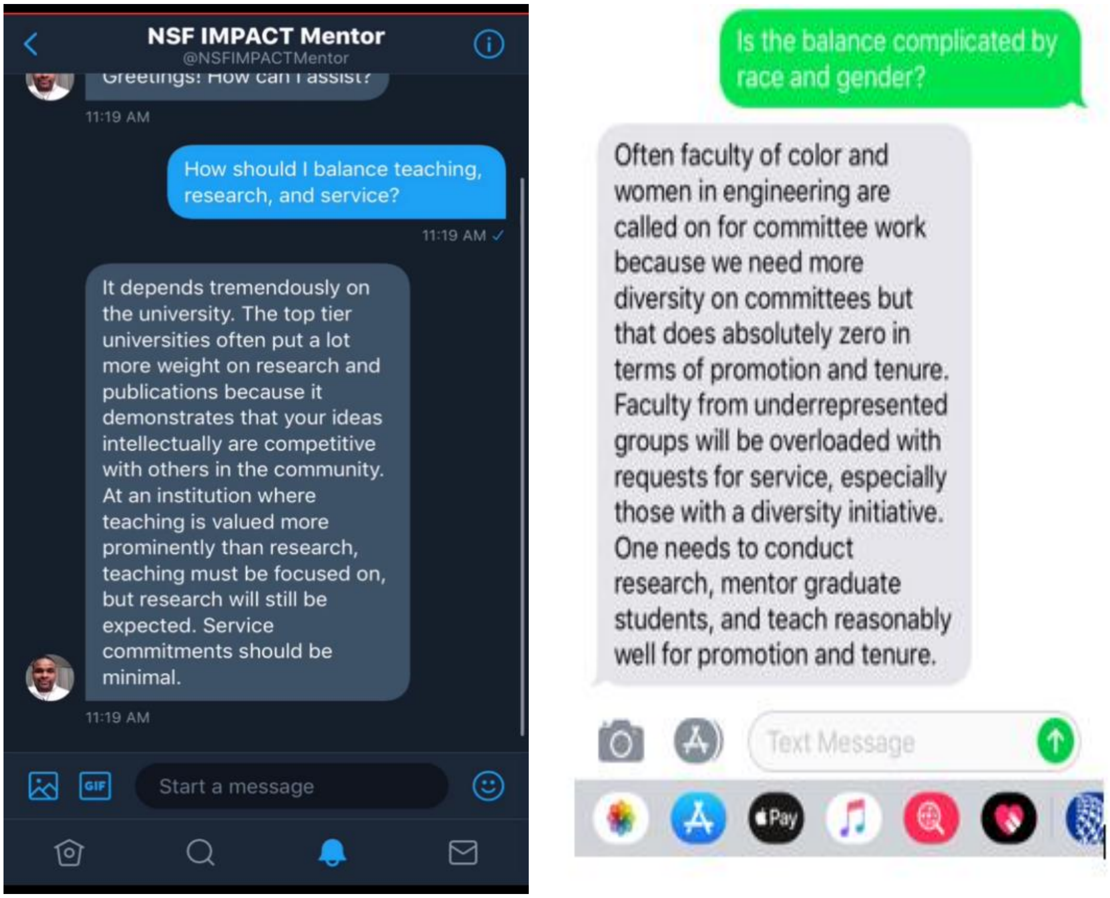

Figure 2. Twitter and text message chatbot examples.

Participants. Two focus groups comprised of five URM doctoral engineering students were conducted to explore the efficacy of the chatbots in future faculty mentoring. Students were pursuing their engineering doctoral degrees from either Georgia Institute of Technology or Emory University and were evaluating whether to obtain a postdoctoral fellow position to eventually enter the professoriate or pursue a career in industry. The variation among participants is displayed in Table 1. Each student was each given a $100 Mastercard gift card for participating in a focus group.

Table 1: *URM 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/Latina	26	Biomedical
5	Female	Black/African American	25	Electrical and Computer
6	Female	Black/Jamaican American	25	Biomedical
7	Female	Black/African American	24	Chemical
8	Male	White/Hispanic	26	Mechanical
9	Male	Black/African American	24	Aerospace
10	Male	Mexican/Filipino	24	Biomedical

Data Collection. Upon obtaining Institutional Review Board approval, URM doctoral engineering students in Atlanta, Georgia were contacted to participate in a focus group on the potential efficacy of utilizing chatbots in future faculty mentoring. All were provided with consent forms detailing the purpose of the study and the focus group procedures, along with a demographic sheet to be completed. 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). Participants began by viewing a series of chatbots developed in text message form, Twitter, and an embodied conversational agent 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). Upon completion of each focus group, all recordings were transcribed.

Data Analysis. A phenomenological approach was utilized for data analysis of the focus group transcriptions by following the systematic application of this method to ensure coding credibility and dependability (Moustakas, 1994). 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 in future faculty mentoring. Inductive and deductive analysis strategies were employed with the Efficacy of Chatbots for Future Faculty Mentoring conceptual framework. The transcripts were then coded in cycles per the guidance of Miles, Huberman, and Saldaña (2013).

The researchers engaged first in reflexivity to examine and foster dialogue on the preconceptions, beliefs, values, and assumptions brought to the study in order to mitigate them in the analysis process. During the first cycle of coding, a thorough review of the focus group transcripts was completed, and analytical memoing occurred in which thoughts, ideas, and initial emerging patterns were noted. The second cycle involved inductive, open coding of significant statements by horizontalization; thus, each statement was read with equal value (Moustakas, 1994). This cycle included identifying in vivo codes using the participants' words and descriptive codes to summarize patterns in the data (Miles et al., 2013). The third cycle employed deductive analysis strategies through coding to the conceptual framework to further understand the data (Moustakas, 1994). The codes and patterns that emerged from the inductive and deductive analyses were compared in the fourth cycle to provide a holistic view of the potential efficacy of utilizing chatbots in future faculty mentoring (Creswell & Poth, 2017). After additional memoing and review of the data, three final themes were identified.

Trustworthiness. Multiple verification strategies ensured the findings were trustworthy (Lincoln & Guba, 1985). In order to address credibility, researchers utilized cross-case synthesis throughout the data analysis process to examine whether the themes were cases of similar or different perspectives of the URM doctoral engineering students (Hayes, 1997). Miles et al. (2013) highlighted the flexibility of this approach when data collection occurs in a phased design. To ensure transferability, thick, rich descriptions were utilized (Patton, 2015). Dependability was addressed by evaluating the manner in which the themes represented the whole of the text (Silverman, 1993; Stake, 1995). Researchers ensured confirmability by validating themes in the early and late stages of the data analysis process (Miles et al., 2013). Dependability and confirmability were accomplished by involving multiple researchers in evaluating and providing feedback on the identified themes, which enabled the comparison of several feedback loops. Application of these verification methods mediated the limitation of including only URM doctoral engineering students who self-selected to be interviewed and self-reported their views and experiences (Lincoln & Guba, 1985; Miles et al., 2013).

Findings

Following data analysis, three themes were identified: (1) mentoring needs of URM doctoral engineering students, (2) chatbot satisfaction, and (3) intent to use chatbot. Thus, the essence of the findings was while URM doctoral engineering students have ample unmet mentoring needs and overall are satisfied with the chatbot, their intent to use the chatbot is mixed due to a lack of personalization in this type of mentoring relationship.

Mentoring Needs of URM Doctoral Engineering Students. The URM 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 doctoral 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 students 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.

Students also shared they tended to rely on a constellation of mentors who were acquired informally to ensure their 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 mentoring 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 mentorship 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 student 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 and trajectory.

Chatbot Satisfaction. Satisfaction with the chatbots was driven by user interface and perceived trust of the emeriti faculty responses. Students shared the interfaces of Twitter, text, and embodied conversational agents 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 chatbot would include a notification system so students could receive information they may not know to ask. She indicated "a notification may by 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 chatbot 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 chatbot 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 Chatbot. While overall students shared a general satisfaction with the chatbots, they expressed concern on the lack of personalization and relationship building that could occur with the chatbot, which resulted in mixed responses on the intent to use. One shared: "What I get from a mentor is the personal connection, personal relationship which helps them identify opportunities that are right for you." 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 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 the chatbot could be leveraged to create 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. One said she would recommend a chatbot to "people who struggle with actually going out and interacting with people and asking questions because a chatbot would benefit them." Students also shared they would utilize a chatbot if searching for timely information, such as professional conferences they should attend or properly citing an industry internship on their curriculum vitae. Another individual stated it 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.

Discussion

One of the major challenges faced by URM doctoral engineering students is securing mentoring relationships that socialize them into the engineering culture and community of practice while offering them 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 indicated a multitude of their mentoring needs were unmet, particularly with the milestones they should be accomplishing, such as securing a postdoctoral fellowship. Those who described successful mentoring relationships personally sought them out and valued those who shared their interests and goals, as well as enhanced their technical skills. The women, in particular, desired a mentor who possessed a similar cultural background, affording the opportunity to relate on a personal, deeper level. While the chatbots in current form were unable to meet the cultural background desire of the students, the perspectives and insights provided by the emeriti engineering faculty was viewed as vital, practical advice on charting the course of their budding academic careers.

The conceptual framework for the Efficacy of Chatbots for Future Faculty Mentoring was useful in interpreting the ways in which the focus group participants 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. Students also believed the emeriti faculty responses were credible and useful, particularly beneficial for those who lacked mentoring relationships, were too shy to ask questions, or were seeking quick, reliable information.

This study demonstrates 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 (Berry et al., 2005; Bickmore et al., 2005; de Carolis et al., 2006; Gosha, 2013; Gosha et al., 2014; Gosha et al., 2018; Marsella et al., 2003). Yet, the cornerstone for true success of these chatbots, as measured by intent to use it, requires a more sophisticated chatbot. Students desire mentorship, even supplemental mentorship, that is tailored 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, which is confirmed by this study (Beale & Creed, 2009; Berry et al., 2005; Bickmore et al., 2005; de Carolis et al., 2006; Lee & Choi, 2017). Students stated additional value could be ascribed to chatbots that connect users with human mentors, which could expand their networks and the potential for future success. Further development includes expansion into these areas, as well as standardizing the process for response creation through additional data collection with a cadre of diverse, renowned engineering faculty, engaging subject matter experts to conduct quality verification checks on responses, testing new responses with potential users, and launching the chatbots for URM future faculty, as well as faculty in general.

Conclusion

No studies have investigated the utility of chatbots in providing mentoring to future engineering faculty. This phenomenological study fills the gap through focus groups with URM doctoral engineering students and provides greater consideration into the unmet mentoring needs of these students, as well as the potential of utilizing chatbots in supplementary mentoring, particularly for those who lack access to quality mentoring. An understanding of the conceptual pathway that can lead to greater satisfaction with chatbots through positive user interface and perceived trustworthiness, and ultimately intent for their use in mentoring, can provide valuable insights on the future of virtual mentoring in an increasingly automated and digitized academic world.

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