Developing a Question Corpus for a Conversational Agent Designed to Prepare Interested Black Undergraduates for the Professoriate in STEM

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***Abstract*—To increase the number of minorities that enter highly demanding computing field, a conversational agent is being developed to serve as a supplemental virtual mentor for minority students pursuing the professoriate. As minority engineering and computing professoriate interest is limited in the literature, it is important to identify the level of interest and concerns minority students have in pursuing the professoriate. A survey was administered to undergraduate students at an HBCU enrolled in one of three computer science courses. The results identify likelihood of pursuing the professoriate, persuasive and discouragement themes for pursuing the professoriate, as well as frequently asked questions over several variables of the minority STEM professoriate experience. Questions and data on question type, grammar, syntax and word choice will be used to improve the knowledgebase of the virtual mentor.**

***Index Terms*—computing interest, minorities in computing, conversational agent, minority advisement**

I. Introduction

As the demand for computer science and engineering increases [1], the substantial underrepresentation of Blacks in the engineering and computing professoriate [2, 3] becomes critical. African Americans make up 13% of the population yet only 4% of all people who are awarded with a bachelors degree in computing [4]. Companies and higher education encounter challenges securing and retaining prepared African Americans in engineering and computing careers [5–7].

One of the prominent factors associated with the proportionately low amount of engineering and computing professors is the lack of interest. Literature on the factors that contribute to disinterest in computing and engineering such as low self-efficacy in STEM [8, 9], expectations of being boring, asocial, lack of cultural orientation [10], and the low representation of minorities in the field [11]. Though limited, it is suggested that factors that increase minority interest in engineering and computing include the fields interdisciplinary and evolving nature, affinity to problem solving, relevance of human-computer interaction, early exposure to technology and related devices [12], and positive social interactions including communal activities [13] and influence from models such as peers, family, and academic staff [14–17]. There are very few data on the interest and perspective of minorities to pursue the professoriate in engineering or computing, however data suggests there are very low levels of tenure-track professors and Ph.D. production [7, 10]. A study interviewing Black women pursuing graduate studies in engineering expressed low self-efficacy in prospective graduate study academic and research performance as well as challenges faced during graduate studies such as poor peer support and lack of institutional understanding and support [9]. It has also been suggested many Black engineering students have low expectations for quality interactions with professors due to the expectation that engineering faculty are focused on scholarly production and not engagement, furthering negative social interactions with the engineering professoriate [16]. Blake [17] suggests students who have an affinity for community uplift, with influential faculty advisors who experienced learning activities prompting an interest in teaching motivates students to serve as faculty at minority serving institutions.

Mentoring is an effective method in modeling underrepresented minority students to pursue the professoriate in engineering and computing [16, 18, 19]. Virtual mentoring can be implemented to accommodate the lack of represented faculty to serve as mentors [16]. Virtual mentoring is the use of distance technology, computer programming, and human input to conduct a mentoring relationship [20]. Virtual mentoring systems program content provided by human mentors into a knowledge database that uses an interface to administer responses to a human mentee . Virtual mentoring allows mentees to store the systems advice and receive advisement in real-time, accessible in a variety of locations. Conversational agents, or chatbots, are a type of virtual mentor that uses interface agents through SMS, social media, or a web-based application to interact with a mentee [21]. A conversational agent grounded in STEM interest and identity development theory and user experience recommendation can address the challenges of Black attrition in the pursuit of the professoriate.

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This paper discusses an exploratory study that serves as an essential early step of a larger study on the effectiveness of a conversational agent mentoring Black STEM undergraduate students interested in pursuing the professoriate at two Historically Black Colleges (HBCUs).

II. Method

A. Participants

An exploratory study was conducted to observe the level of interest and the questions minority students have in pursuing the professoriate in STEM. A total of 71 participants were assessed during the study. All participants were HBCU students enrolled in a computer science course. Recruitment was performed through word-of-mouth within a three computer science courses. All participants who were interested in participating in the study were included. Participants ages ranged from 18-25. All participants were minorities (90% Black/African American, 1% Native American, and 5% other). To generalize for academic performance, participant GPAs ranged from 2.4-4.0 on a 4.0 scale. Though most participants were computer science majors, other majors included engineering, applied physics, economics, mathematics, business finance, biology, and psychology. The sex of the participant was not determined; given the institution was an all-male institution that allows for cross-registering with neighboring institutions that serve female students, it is to be assumed that the majority of the students were male.

B. Materials and Procedure

Participants were tasked to complete an online survey. The survey consisted of three parts: (1) demographics, (2) graduate school and professoriate interest, and (3) professoriate question inquiry. The demographic section asked about participants age, ethnicity, academic classification, academic performance, and major. The graduate school and professoriate interest section included questions on if participants were interested in, the likelihood of attending, and factors that persuade and dissuade students from graduate school and the professoriate. The professoriate question corpus development section asked participants to write three questions they would ask a mentor for pursuing the professoriate. Participants completed the survey online using Qualtrics, an online survey and research software tool.

C. Data Analysis

The graduate school and professoriate interest section included three types of questions. Interest questions were yes-no questions and likelihood questions were Likert scale. Percentages of all participants per response were used as analysis.. also using percentages to analyze, using a top-two box approach to calculate favorability.

Persuasion factors and students questions were analyzed using a thematic analysis approach (Fereday). Codes were determine before analyzing the data using research experience, coursework experience, graduate school application, graduate school funding, graduate school selection, computing professoriate experience, and minority/Black STEM professoriate experience. These categories were determined by observing a series of graduate program frequently asked question pages [NCAT, 2018; MIT, 2018; UCLA, 2018; UCLA, 2018] and supported by literature on academic mentoring [[16, 18, 19] (see Table 1 and 2 for codes). No quality appraisal form was completed for these survey items. Themes were determined by synthesizing the responses provided by participants.

TABLE I
Graduate School and Professoriate Interest

Topic	Themes
Graduate School Persuasion	Increase education, increase income, increase job performance
Graduate School Persuasion	Securing funding, not making money, time commitment
Professoriate Persuasion	To encourage students, high pay
Professoriate Dissuasion	Salary amount, lack of interest

Note. Table 1 shows saturated themes from participants persuasive reasons to attend graduate school and the professoriate and dissuasive reasons not to go to graduate school and the professoriate.

III. Results

A. Graduate School and Professoriate Interest

The graduate school and professoriate interest section observed participants interests and likelihoods for attending graduate school and pursuing the professoriate. Of the sample, 65% were interested in going to graduate school and 40% were interested in pursuing a career as a professor in STEM. The likelihood (will and will likely) to pursue graduate school was 65.28% , and 23.61% (will and will likely) for pursuing a career as a STEM professor.

Participants were also asked about factors that persuade and dissuade them from pursuing graduate school and the professoriate. frequent persuasion and dissuasion themes are included in Table 1. Other notable graduate school persuasion comments include being more credible and pursuing if the opportunity was completely paid for. Other frequent graduate school dissuasion comments include the interest to work more than attend school and the workload associated with graduate school. A few additional comments that stand out about professoriate persuasion are that they are very interested in STEM, thus would not mind being a professor and the job security. Participants also included that lack of enjoyment in the profession, rigor of the role, and their belief on being not well-suited for the roles associated with being a professor dissuade them from pursuing the professoriate.

B. Professoriate Question Corpus Development

Questions varied between each category. The most frequent themes are listed in Table 2. There were other notable results. Additional research experience questions included how to prepare for graduate school research in undergrad, paid research, research types, internships, and workload. For coursework experience, participants also added questions about what to expect for graduate school coursework, entering a computing

TABLE II
PROFESSORIATE QUESTION INQUIRY

Codes	Themes
Research Experience	Why is research important/needed? How much time will I spend doing research in graduate school? Is it important to attend research talks and/or conferences?
Coursework Experience	How important is an undergraduate minor? How heavy is the workload in graduate school? How can I prepare myself academically in undergrad for graduate school?
Graduate School Application	How should I organize/write my statement of purpose? How do I apply to graduate school? How long is the graduate school application process? How important are GRE score?
Graduate School Funding	How do I secure funding? How do I apply for scholarships?
Graduate School Selection	How important is a schools location? How do you determine the graduate programs credibility? How do I choose between different graduate program options?
STEM Professoriate	How much do STEM professors make? How do I find an opportunity after a graduate school program? How important is networking as a professor?
Black STEM Professoriate	Is it beneficial to be a minority professor? Is being a professor more challenging as a minority?

Note. Table 2 shows saturated themes of questions participants had about pursuing the professoriate and graduate school separated by seven codes.

graduate program without a bachelors degree in computing, and the GPA needed for graduate school retention. For graduate school application, participants asked about the weight of GPA, letters of recommendation, application costs, and application requirements. For graduate school funding, additional participant questions included departmental funding, funding amounts, FAFSA, time allotted to secure funding, and funding types. For the graduate school selection category, participants included questions about residency, determining job-placement after completion of the program, institution and program culture, and researching faculty. For STEM professoriate questions, participants asked about requirements to complete a PhD program, teaching options, and research expectations. For Black STEM professoriate, participants included on questions on discrimination and microaggressions, school preferences based on the population attending the institution and program, networking, and satisfaction at work.

IV. DISCUSSION

Most students were interested in and likely to pursue graduate school which raises questions on the career paths many underrepresented minority STEM students are pursuing in which they would want to pursue graduate-level education. there was a substantial percentage that could increase the number of minority professors [2]. This suggests there is a widespread demographic for such a tool to be used.

The graduate school and professoriate persuasion and dissuasion questions give insight to the value and perspective undergraduate minority students. In both persuasion and dissuasion from graduate school and the professoriate, money seemed to be the center focus in pursuit. Many participants were interested in high salary and repelled from time spent away from accumulating income, spending money in pursuit, and the chance of not having a remarkable salary. Exploring the effects of capitalism and socioeconomic condition in minority communities is yielded from these results. There were many reasons to pursue graduate school, such as increasing education, job performance, improved research abilities, and credibility; whereas the professoriate responses were more limited falling into three categories: lack of interest, settling/retiring into a career as a professor, professor is a goal. As graduate school has many purposes, the professoriate is a specific career type that understandably may not be for everyone [1]. For those interested in pursuing a career as a professor, persuasive factors ranged from research freedom, to hands-on work, and even simply enjoying teaching. The more frequent themes included participants in the settling category, where they were persuaded by job security, having a general interest in STEM, and being a post-industry route. Interestingly, many agreed, even those claiming not to be very interested in the professoriate, that impacting and mentoring students was a major persuasive factor to pursue the professoriate. This supports theories on the salience of social relevance, mentorship, and modeling in minority communities [16, 18, 19].

Participants questions allowed the research team to import direct questions presented by students into the mentoring chatbot system to be used in further investigation on how virtual mentorship can be leveraged to improve the preparedness and attitudes of minority students pursuing careers as a professor in STEM [20, 21]. Users will be able to ask such questions, receive answers in real time and their answers will be saved in the text dialogue. This proved to be useful in many ways. Firstly, the findings present focal areas in which students who are interested and value graduate school and professoriate experience would be curious about. The frequent themes are representative of the values of undergraduate computing students in pursuing the professoriate (see Table 2). Research themes focused on purpose, which is essential for motivating students to continue research works, but very broad and base-level which may infer many students are not currently deeply involved in research. On the other hand, coursework questions were more detailed, most around the level of rigor and workload, suggesting self-efficacy is an area of interest for modeling efforts. Graduate school questions varied between the aspects of the application process. Funding questions, like research questions, were very general, yet process-focused rather than rationale-focused. Graduate school selection questions were the most engaging, featuring deeper advisement questions such as differentiating between options. STEM professoriate questions stemmed more on the lines of general occupation questions independent from the

STEM professoriate such as pay, job search, and networking. Very few questions were deeply rooted in the role of a STEM professor. Black STEM professoriate questions were ranged from purpose to prospective everyday experiences to demographic preference of the institution a professor instructs.

Secondly, the questions suggested the depth in which students would ask questions to the mentoring chatbot. Depth can be explained in four simple categories: general facts, specific facts, general advice, and specific advice. General facts are objective answers that, most likely, could be found in simple searches elsewhere. For example, what is a fellowship? is as general fact questions warranting a general fact answer. Specific facts are facts that are challenging to answer broadly an may often vary between contexts. For example, what fellowship at State University pays the most? is a specific question, specified by an institution variable which would warrant a general response if the answer is not known by a virtual mentor database such as reach out to the financial aid administrators at the institution. General advice is a process question that should warrant a response to affect a users behavior. Advice questions should invoke different behavioral responses based on the level of preparedness a user is. Specific advice questions are the most useful in mentoring relationships and typically will be dependent upon the mentees level of preparedness and expertise. Most frequent themes were general advisement questions. Such questions are important to affect a students performance and attitudes towards graduate school and the professoriate. Such questions will need to be supplemented with specific advisement questions for mentee users to get to the deeper questions a student user may be trying to answer and to perform more closely as an effective mentor.

Finally, the questions allowed the research team to detect trends in grammar and syntax students would input questions into the mentoring chatbot. Detecting word choice and grammar helps the researchers discover different intents. Common grammar and syntax trends include the use of acronyms (MBA, HBCU, HCI, etc.), interrogative word misuse such as is-are and is-does, and incomplete sentences in context, for example prompted about graduate school how do I apply rather than how do I apply to graduate school. Word choice inputs to look out for included the words good, best, need, help, important; these words can be problematic in determining the more specific intention of the user.

1) Limitations: There were a few limitations to the study. Firstly, sex was not determined and it is very likely most all of the participants were male. Generalizability to female participants is to be cautioned. Also, the survey instrument used was not and did not include validated scales. As much of the data was qualitative and exploratory, the survey served more similarly to an interview. However, there was no reliability and validity testing for the qualitative interest questions. For an exploratory study determining the types of questions a user would input into a mentoring chatbot, the method was not authentic to the experience a user would encounter. Not only did users not input the questions directly into a chatbot (questions were inputted through an online survey), but users were prompted the categories to ask actual questions they had about graduate school and the professoriate. This effort was to ensure users would ask a range of experience questions for many topics increasing the knowledge base and scope of the chatbot, which may not have been produced with purely inductive practices and analysis [fereday]. With each category, a sample question was added so participants would have an idea of the type of questions to ask the survey. These questions consequently served as a prime, where participants would ask the same or similar questions to the topic of the sample question. The following frequent themes were influenced by sample question priming: research talks, undergraduate minor, statement of purpose, school location, and networking as a STEM professor. As a prime, it cannot be concluded the influenced frequent themes reflected the values of the minority undergraduate computing students. STEM professoriate and Black STEM professoriate had substantially less valid question responses than the other five categories; being particularly low in Black STEM professoriate. As all participants were not interested in pursuing the professoriate, this is understandable. However, the Black STEM professoriate suffered in frequent data due to low quantity, but also due to a wider spread of question topics than some of the other topics. This may suggest the element of ethnicity may be more intricate than the other topics and requires further research in the best practices to implement knowledge to the mentoring chatbot on such matters.

V. Conclusion

STEM identity is a highly influential factor that affects the academic performance a minority student. STEM identity continues to be explored and its relationship with academic performance. Quantitative data on the interest of pursuing the professoriate in engineering and computing reflects the sample, and my not be generalizable for all Black computing undergraduate students; however, the descriptive statistics provide insight on how persuasion, discouragement, and question-focus relates to a populations interest. Pedagogical and preparatory tools should use STEM identity research to help develop their tools, especially in efforts to integrate minority students.

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References

[1] B. of Labor Statistics, "Fastest growing occupations, 2016 - 2026," 2018.

[2] S. Lewis, C. Simon, R. Uzzell, A. Horwitz, and M. Casserly, "A call for change: The social and educational factors contributing to the outcomes of black males

in urban schools." *Council of the Great City Schools*, 2010.

[3] B. DiSalvo, M. Guzdial, C. Meadows, K. Perry, T. McKlin, and A. Bruckman, "Workifying games: successfully engaging african american gamers with computer science," in *Proceeding of the 44th ACM technical symposium on Computer science education*. ACM, 2013, pp. 317–322.

[4] S. Zweben and B. Bizot, "2014 taulbee survey," *Computing*, vol. 27, no. 5, 2015.

[5] A. P. Carnevale, N. Smith, and M. Melton, "Stem: Science technology engineering mathematics." *Georgetown University Center on Education and the Workforce*, 2011.

[6] Z. S. Wilson, L. Holmes, M. R. Sylvain, L. Batiste, M. Johnson, S. Y. McGuire, S. S. Pang, I. M. Warner *et al.*, "Hierarchical mentoring: A transformative strategy for improving diversity and retention in undergraduate stem disciplines," *Journal of Science Education and Technology*, vol. 21, no. 1, pp. 148–156, 2012.

[7] L. Charleston, J. Gilbert, B. Escobar, and J. Jackson, "Creating a pipeline for african american computing science faculty: An innovative faculty/research mentoring program model," *The Journal of Faculty Development*, vol. 28, no. 1, pp. 85–92, 2014.

[8] T. L. Strayhorn, "Factors influencing black males' preparation for college and success in stem majors: A mixed methods study." *Western Journal of Black Studies*, vol. 39, no. 1, 2015.

[9] Q. R. Alexander and M. A. Hermann, "African-american womens experiences in graduate science, technology, engineering, and mathematics education at a predominantly white university: A qualitative investigation." *Journal of Diversity in Higher Education*, vol. 9, no. 4, p. 307, 2016.

[10] J. E. Gilbert, J. F. Jackson, E. C. Dillon Jr, and L. J. Charleston, "African americans in the us computing sciences workforce." *Commun. ACM*, vol. 58, no. 7, pp. 35–38, 2015.

[11] A. N. Washington, L. Burge, M. Mejias, K. Jean-Pierre, and Q. Knox, "Improving undergraduate student performance in computer science at historically black colleges and universities (hbcus) through industry partnerships," in *Proceedings of the 46th ACM Technical Symposium on Computer Science Education*. ACM, 2015, pp. 203–206.

[12] L. J. Charleston, "A qualitative investigation of african americans' decision to pursue computing science degrees: Implications for cultivating career choice and aspiration." *Journal of Diversity in Higher Education*, vol. 5, no. 4, p. 222, 2012.

[13] K. L. Boucher, M. A. Fuesting, A. B. Diekman, and M. C. Murphy, "Can i work with and help others in this field? how communal goals influence interest and participation in stem fields," *Frontiers in psychology*, vol. 8, p. 901, 2017.

[14] J. McCormick, S. B. Alavi, and J. Hanham, "The importance of context when applying social cognitive theory in organizations," *Handbook of Research on Management Ideas and Panaceas*, pp. 110–129, 2015.

[15] C. Sedikides, V. Hoorens, and M. Dufner, "Self-enhancing self-presentation: Interpersonal, relational, and organizational implications." 2015.

[16] C. B. Newman, "Rethinking race in student-faculty interactions and mentoring relationships with undergraduate african american engineering and computer science majors," *Journal of Women and Minorities in Science and Engineering*, vol. 21, no. 4, 2015.

[17] D. Blake, "Motivations and paths to becoming faculty at minority serving institutions," *Education Sciences*, vol. 8, no. 1, p. 30, 2018.

[18] D. J. Davis, "Access to academe: The importance of mentoring to black students," *Negro Educational Review*, vol. 58, no. 3/4, p. 217, 2007.

[19] J. I. Clark, S. L. Codd, A. C. Des Jardins, C. M. Foreman, B. W. Gunnink, C. Plumb, and K. R. Stocker, "Peer mentoring program: Providing early intervention and support to improve retention and success of women in engineering, computer science, and physics," in *Proceedings of American Society for Engineering Education*, 2015.

[20] A. Miller and J. Kay, "A mentor program in cs1," *ACM SIGCSE Bulletin*, vol. 34, no. 3, pp. 9–13, 2002.

[21] T. Bickmore and J. Cassell, "Relational agents: a model and implementation of building user trust," in *Proceedings of the SIGCHI conference on Human factors in computing systems*. ACM, 2001, pp. 396–403.