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Virtual Graduate School Mentoring Using Embodied Conversational Agents

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Abstract

It has been a major goal of the United States government to increase the participation of Americans in the fields of Science & Engineering (S&E), especially in under-represented groups. This research examines the use of an embodied conversational agent (ECA) as a virtual mentor to African American undergraduates who are interested in pursuing a graduate degree in computing. Mentoring advice was collected from a group of experts and programed within the ECA. A between-group, mixed method experiment was conducted with 37 African American male undergraduate computer science majors where one group used the ECA mentor while the other group pursued mentoring advice from a human mentor. Results showed no significant difference between the ECA and human mentor when dealing with career mentoring functions. However, the human mentor was significantly better than the ECA mentor when addressing psychosocial mentoring functions.

Keywords: agent, conversational, embodied, graduate, mentoring, virtual

I. Introduction

In a 2007 report by the National Academy of Science (Rising, 2007), the case is made if the United States wants to maintain its global competitiveness it must continue to research and innovate in the areas of science and engineering (S&E). To achieve this goal, a 2011 report by the National Academies of Science (Expanding, 2011) highlights the importance of increasing the participation of under-represented minorities due to their increasing make up of the United States population.

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One under represented group is African Americans in computer science. According to the 2011 Taulbee Survey (Taulbee, 2011), representing 184 PhD granting universities, African Americans represent 1.4% of all computer science faculty even though they make up 12.6 percent of the total population (Humes, Jones, & Ramirez, 2011). The small percentage of African American faculty can be attributed to the small percentage of African American students in computing. These students also have disproportionate numbers with 3.6% of computer science bachelor degrees awarded, 1.6% of master's degrees awarded and 1.2% of doctoral degrees awarded in 2011.

Several interventions increase participation for under represented minorities were discussed in the 2011 National Academies (Expanding, 2011) report including mentoring. In this research, a virtual human, otherwise known as an embodied conversational agent (ECA), was used to mentor African American undergraduate computer science majors who are interested in pursuing graduate degrees in computing. It is hypothesized by the authors that this "virtual mentor" could provide mentorship comparable to a human mentor.

II. Literature Review

A. Mentoring Functions

Mentoring can be defined as a dynamic, reciprocal relationship in a work environment between an advanced career incumbent (mentor) and a beginner (protégé) aimed at promoting the career development of the mentee (Healy & Welchert, 1990). Mentoring has traditionally been divided into two primary functions, career and psychological (Kram, 1983). The career-related functions include "nominating the protégé for desirable projects, lateral moves, and promotions (sponsorship); providing the protégé with assignments that increased visibility to organizational decision makers and exposure to future opportunities (exposure and visibility); sharing ideas, providing feedback, and suggesting strategies for accomplishing work objectives (coaching); reducing unnecessary risks that might threaten the protégé's reputation (protection); and providing challenging work assignments (challenging assignments)" (Noe, 1988).

Psychosocial functions identified by Kram (1985) include “serving as a role model of appropriate attitudes, values, and behaviors for the protégé (role model); conveying unconditional positive regard (acceptance and confirmation); providing a forum in which the protégé is encouraged to talk openly about anxieties and fears (counseling); and interacting informally with the protégé at work (friendship)” (Noe, 1988). In this research, both career and psychosocial mentoring functions are measured.

B. Mentoring Constellations

Mentoring research has typically been conducted within traditional organizational settings with traditional, dyadic mentor-protégé relationships (Kram, 1985). In more recent mentoring manuscripts, a new model of mentoring has been emerging that encourages a broader, more flexible network of support, in which no single person is expected to possess the expertise required to help students exclusively (Sorcinelli & Yun, 2007). In this model, junior faculty-to-senior faculty relationships as well as doctoral student-to-faculty rely on “mentoring partners” in non-hierarchical, collaborative, cross-cultural partnerships known as multi-mentor networks or mentoring constellations (Sorcinelli & Yun, 2007). In a 2003 article (Mathews, 2003), Matthews provides a framework for mentoring that suggest that given the varied components of academic work, mentoring is best undertaken by a number of faculty members, rather than by one individual.

Other studies have confirmed the relationship of having a network of mentors compared to just a single mentor will enhance career success and personal well-being (de Janasz, 2004; Girves, 2005; Johnson, 2007). In a study by van Emmerik (van Emmerik, 2004), it was found that having multiple mentors is not a substitute for a single mentor but should be held in addition to a core relationship. In a 2002 study of formal mentoring programs (Cawyer, Simonds, & Davis, 2002), the authors concluded that the most important feature of mentoring constellations might be accessibility to the mentors in that particular constellation. In studies conducted by Eby (Eby, 1997) and McManus and Russell (McManus & Russell, 1997) it was deduced that, depending on the research perspective, a mentor may not be from within the same organization as the protégé and it is actually optimal if the network of mentors come from different organizations due to a reduction in information redundancy (Higgins & Kram, 2001).

In a 2000 study (Peluchette & Jeanquart, 2000), it was found that multiple mentors where used by early career professionals to seek emotional support. That same study also found that mentoring constellation patterns changed according to the career stage of the protégé (Peluchette & Jeanquart, 2000). Based on the research in mentoring constellations, an ECA mentor could possibly co-exist with other human mentors rather than replace them.

III. Methods

A. Participants

A total of 41 junior and senior Computer Science majors were enrolled at the college at the time of the study. Results from the power analysis recommended a minimum of 36 of the 41 students participate in the study assuming a 5% margin of error, 90% confidence level and a 50% confidence distribution. Of the participants who participated, 19 used the virtual mentor and 18 interacted with a human mentor.
Participants used in the study were selected using convenience sampling since the sampling frame had over 150 elements. Since the content of the relational agent was customized for African American male computer science majors, it was a requirement that each participant be an African American male computer science major. Additionally, every participant had to be somewhat interested in graduate school, be at least 18 years old and enrolled in good standings at the institution where the study was conducted.

Of those who met the criteria above, participants were selected using purposeful sampling, rather than probabilistic or any other sampling method, ensuring that feedback was collected from students who had various experiences from their mentoring experience. Potential participants were informed about the study using a flyer as well as email.

B. Materials and Measures

The research variables in this experiment were divided into two groups – independent and dependent variables. The independent variables addressed in this research primarily came from user demographics that included the following: age, major, minor, classification (i.e. freshman, sophomore, etc.), school, grade point average and ethnicity. Other independent variables included the following:

1. The interest in pursuing a graduate degree in computing
2. Confidence in getting accepted into a graduate program
3. Knowledge about the graduate school application process
4. Knowledge of graduate school funding options
5. Knowledge of career options with a graduate degree in computing
6. Knowledge of graduate school terminology
7. The relationship they had with the agent

The primary dependent variables that were addressed in this research consist of the knowledge learned about graduate school in computing and interest in pursuing a graduate degree in computing.

The virtual mentor concept consists of an ECA programed with mentoring content made accessible by a web browser. The ECA was developed using the Sitepal avatar creation tool at SitePal.com. The tool allowed for the selection of the avatar, the language spoken, the background image and facial expression of the persona.

Many steps were taken to construct the graduate school mentoring agent. First, the subject areas for the content that would be utilized by the mentor had to be selected. Second, questions from the selected area had to be created and asked to a series of experts. Third, an analysis was done of the answers provided by the experts, and generic responses were created for the list of questions. Fourth, a framework had to be selected or built from scratch to handle the input from the user of the system. Since the decision was made to create the agent from scratch, the code had to be written to process the users' input, compare the processed text with the content stored to the agent, and respond to the user. Fifth, the design and construction of the humanoid appearance of the agent was done using the SitePal avatar creation tool on the SitePal website. Sixth, a database was constructed to collect data provided by the participants. Lastly, a website was created to host the agent and the system software. The sections below describe each step in more detail.

Due to the vast amount of data that would have to be compiled and verified for every STEM degree and every single conversational topic, a sample of two topics related to graduate school study for one major, computer science, was collected.

In order to identify two areas of interest by the initial users of the system, a survey instrument was constructed and distributed to a group of students from the computer science majors at the institution where the study was conducted. Once the survey instrument was constructed, it was submitted and approved by the Institutional Review Board (IRB) at both the institution were the study was conducted and the home institution of the author. A total of 60 students were surveyed. One survey was incomplete and discarded leaving a total of 59. The 59 students included 6 freshmen, 16 sophomores, 18 juniors and 19 seniors. Students were solicited using a flyer and given a box of movie-style candy as an incentive. Each student was instructed to rate their interest using a five point Likert scale when answering the following questions:

1. How do I obtain funding to attend graduate school?
2. How should I select a graduate school?
3. How do I select a graduate research advisor?
4. How do I apply for graduate school?
5. Why should I attend graduate school?
6. What are the duties as a graduate student?
7. How do I obtain letters of recommendations?
8. How do I complete an admission essay?
9. What are the differences between a Masters and a PhD?
10. What are the career options with a PhD?
11. What are the salary ranges for PhD graduates?
12. What are graduate courses like?
13. What can I do to start preparing for graduate school now?

Of the 13 questions above, the two highest rated were the questions about funding graduate school (Mean = 4.64, SD = 0.8) and career options with a PhD (Mean = 4.54, SD = 0.7). Due to the popularity of these topics, questions were asked that fit into these two categories.

The participants using the virtual mentor interacted with the agent using an Apple 21.5-inch iMac computer with a 2.5GHz Quad-Core Intel Core i5 processor and an NVIDIA GeForce GT 640M graphics processor with 512MB of GDDR5 memory. Each participant was given Sony MDR NC40 noise cancelling headphones to hear the virtual mentor and remove noise from the room. Users navigated the website with the agents using a full-size Apple wireless keyboard and a multi-touch magic mouse.

C. Procedure

The group that used the virtual mentor started by completing the pre survey. After the survey they sat at a desktop computer that already had the website loaded with the conversational agent. The virtual mentor, Lamar, told participants that he only knew about graduate school funding options and career options. However, participants were still able to ask questions that did not fit into these categories. Unfortunately, Lamar told the participants that he did not know an answer to their questions. This is the script that Lamar told participants upon accessing the website: “Welcome to the Virtual Mentorship System. My name is Lamar. I am here to mentor you about your possible decision to attend graduate school. I currently know mostly about funding options for graduate school and career options if you obtain a graduate degree in computing. Please fill out the information on the left and submit to begin.”

Participants were not given a time limit or maximum number of questions that they could ask the virtual mentor. After the single session, each participant immediately completed the post survey.

Students who participated in the study were randomly assigned to one of two groups. One group of participants was mentored by the virtual mentoring agent. The other group was asked to get mentoring advice from a qualified human mentor. Minimum qualifications for the mentor included the following:

1. An African American who had completed, or was in the process of completing a terminal degree in a STEM field.

2. Anyone who had worked in a job where a component of the job was to advise African American STEM students on graduate school opportunities.

Students were given the names of five individuals who met the above qualifications and worked at the school where the participants were enrolled. Three of those individuals worked in the same building where the participants currently took courses. Students were not restricted on which mentors to select.

The participants chosen for the human mentorship were provided names of three individuals on campus that they could interact with to learn more about graduate school. All three individuals were told about the experiment in advance. The individuals consisted of two faculty members in the computer science department with terminal degrees and the Director of the Office for Research Careers for the Division of Science and Mathematics. Participants were directed to meet with one of the individuals above or anyone else they feel that could provide quality advice about going to graduate school. In addition, participants were instructed to have only a single graduate school advisement session with this person until they completed their post survey and interview (if selected). There were no time constraints or question limitations between the participant and the mentor. Question topics asked by the participant were not restricted as well. Once the session was complete, the participant was to contact the principal investigator to set up the completion of the post survey.

The survey instruments were distributed in a quiet classroom at the home institution of the study participants. The surveys were distributed and collected based on the preference of the participant and availability of the author, Monday through Friday of the fall semester of 2012, and between the hours of 10:00 AM and 5:00 PM. Two surveys were given and collected for every participant in the study. The first survey was given and collected before participants began their mentoring interaction and the second survey was given and collected no more than five days after their mentorship experience. A five day window was used in hopes of limiting any memory loss about the experience. Both survey instruments where distributed and collected solely by the author. Questions on the survey instrument incorporated open-ended as well as closed-ended questions. Additionally, both instruments contained a combination of questionnaire type questions, attitudinal scale questions and achievement questions.

A pool of participants from both groups (those that used the virtual mentor and those who used a human mentor) were interviewed after completing their post study. These participants were selected using a convenience sampling method. Participants were contacted in person, at random and asked if they wanted to participate in a brief interview. Before conducting the interview, each participant was given introductory remarks about the study and was asked again for an informed consent.

Each interview was audio recorded and transcribed with an online voice transcription service called Fox Transcribe. In addition to asking for an overview of their experience with their mentor, the following five questions were asked:

1. What did you learn from your experience with your mentor?
2. What could have made your mentorship experience better?
3. What impactful things did you learn from your mentorship experience?
4. What changes will you make after your mentorship experience?
5. How will you describe the relationship between you and your mentor?

Additional questions were then asked depending on the responses of the participant. After the conclusion of the interview, the participants were thanked for their cooperation.

IV. Results

A power analysis was performed to find a reflective sample size for the study. A total of 41 junior and senior Computer Science majors were enrolled at the college at the time of the study. Results from the power analysis recommended a minimum of 36 of the 41 students participate in the study assuming a 5% margin of error, 90% confidence level and a 50% confidence distribution. Of the participants who participated, 19 used the virtual mentor and 18 interacted with a human mentor.

To test for significant differences in scores from pre-evaluation to post-evaluation, a paired samples t-test for each group (human mentorship and virtual mentorship) was performed. This parametric technique compares sample scores across two time periods (a within-group analysis). In short, this addresses the question: is human or virtual mentorship effective at all? It is important to note that this inquiry must be answered before asking which experience is more effective than the other in the mentorship of undergraduates.

Because no statistical assumptions have been violated in this sample, a similar, yet alternative test, the Wilcoxon Signed Rank test, was not implemented. Also, given that the study only had two groups (human and virtual) a repeated measures analysis of variance was not used. This analysis would have allowed for comparative analysis across three or more groups.

Human Condition- Paired Samples T-Test Results (Pre-Post)						
Section 1 Items	**Pre-Test (μ, SD)**	**Post-Test (μ, SD)**	**Mean difference**	**t-statistic**	**Sig. Value**	**Cohen's D**
1. I am interested in pursuing a graduate degree in computing	(4.06, 1.10)	(4.17, .985)	-0.111	-.356	.726	-
2. I am interested in pursuing a doctoral degree in computing	(3.76, 1.20)	(4.12, 1.11)	-0.353	-1.102	.287	-
3. I feel confident I can get admitted into a graduate program	(3.94, 4.39)	(4.39, .698)	-0.444	-1.917	.072	-
4. I feel confident I will do well as a graduate student	(4.22, .938)	(4.33, .686)	-0.111	-.566	.579	-
Interest & Confidence Subscale (Items 1-4)	(4.00, .773)	(4.22, .742)	-0.22	-0.99	.339	-
*Indicates a statistically significant difference from the pre-test score at the $p < .05$ level.						

Human Condition- Interest & Confidence Subscale Reliability		
Pre / Post Subscale	**Cronbach's Alpha**	**Number of Items**
Interest & Confidence Subscale (Items 1-4) Pre-Test	.725	4
Interest & Confidence Subscale (Items 1-4) Post-Test	.828	4

Virtual Condition- Paired Samples T-Test Results (Pre-Post)						
Section 1 Items	Pre-Test (μ, SD)	Post-Test (μ, SD)	Mean difference	t-statistic	Sig. Value	Cohen's D
1. I am interested in pursuing a graduate degree in computing	(3.83, 1.58)	(4.11, 1.13)	-0.28	-1.57	0.135	-
2. I am interested in pursuing a doctoral degree in computing	**(2.73, 1.91)**	**(3.27, 1.75)**	**-0.53***	**-2.48**	**.027**	**-0.29**
3. I feel confident I can get admitted into a graduate program	(3.65, 1.32)	(4.06, 0.90)	-.412**	-1.95	.069	-0.36
4. I feel confident I will do well as a graduate student	(4.18, 1.07)	(4.12, 1.05)	.060	.324	.750	-
Interest & Confidence Subscale (Items 1-4)	(3.49, 1.10)	(3.86, 0.987)	-0.38*	-2.52	.021	-0.35

Note: The Likert scale ranges from 0 (Strongly Disagree) to 5 (Strongly Agree)
*Indicates a statistically significant difference from the pre-test score at the $p < .05$ level.
** Indicates a difference that is approaching a statistically significant level

Virtual Condition- Interest & Confidence Subscale Reliability		
Pre/Post Subscale	Cronbach's Alpha	Number of Items
Interest & Confidence (Items 1-4) Pre-Test	.551	4
Interest & Confidence Subscale (Items 1-4) Post-Test	.750	4

Paired samples t-tests revealed mixed results across items. For instance, in the human condition, there were no statistically significant differences in items 1-4. The lack in significant difference from every item (and ultimately the interest and confidence subscale) suggests that this group may have already had high levels of interest and confidence in pursuing graduate school, to the point where a mentorship intervention would only have marginal positive effects. This is known as a "ceiling effect." Conversely, for the same subscale, students in the virtual mentorship condition did have one occurrence of significant difference. Item 2 did experience significant gains in interest and confidence in pursuing graduate studies in computing. A Chronbach's alpha of over 0.7 on three of the four subscales suggests a satisfactory level of internal consistency of the survey questions.

The difference in means in the virtual group and the insignificant difference in means in the human group was an alert to check for the potential of confounding influence of pre-existing group differences. An independent samples t-test that compared student responses to the "interest and confidence" subscale revealed no statistically significant differences. Additionally a one-way analysis of covariance also failed to show significant differences in the impact of intervention, while controlling for pre-test scores. If there were initial significant differences in "interest and confidence" between the two groups (at time 1) this would question true random experimental assignment and thus would be considered a type I error. It is inferred that participants in the virtual mentorship group showed significant gains because they so happened to have lower averages at time one (M =3.67) compared to the human mentorship group (M = 3.99). To reiterate, these surface differences have been nullified as indicators of pre-existing, confounding differences.

In the virtual condition, the difference in interest and confidence from time 1 to time 2 had a small effect with a Cohen's D of 0.35 (d = 0.35). Cohen's D is a statistical value that measures effect size and explains the magnitude of a significant difference once one is established. It presents a *standardized* difference between means. For future reference, the strength of different effect sizes tends to reflect the following scale: $d \leq 0.4$ (small effect), $0.5 \leq d < 0.8$ (medium effect), $d \geq 0.8$ (large effect). In summary, human mentorship had no effect on the variance of scores for items relevant to "interest and confidence," whereas virtual mentorship had a small effect. These findings should *not* be interpreted as one mentorship style being more effective than the other.

Because virtual mentorship students in the pre-trial yielded less than sufficient scale reliability (a Chronbach's alpha less than .70) the results should be closely examined item-by-item with marginal emphasis on comparing these particular subscales.

Changes in students' knowledge about graduate school funding (where numerous items were statistically encapsulated in the "funding knowledge" subscale seemed to be more uniformed across both human and virtual groups. Only item 14 (familiarity with organizations) for the virtual condition had a p-value of over 0.05. This suggests the virtual treatment did nothing to significantly change participants' familiarity with organizations that could provide the user more information about pursing a graduate degree in computing. Overall, the human and virtual mentorship groups had statistically significant differences across time periods ($p < .05$) and large effect sizes where Cohen's $d = 1.46$ and 0.91 respectively. This indicates that gains in "funding knowledge" (see subscale) were largely accounted for by mentorship immersion. In essence, simply engaging with some type of mentor contributed to increases in knowledge about graduate school funding. Lastly, a Chronbach's alpha of well over 0.7 on all of the four subscales suggests a satisfactory level of internal consistency of the survey questions.

With regard to the miscellaneous open-ended items, there were positive changes (ranging from medium to large effect sizes) amongst various items, presumably due to sheer mentorship engagement. In the human condition, items 16, 18, 19 and 20 produced significant changes in the means with p-values all under 0.05. Cohen's D ranging from -0.67 to -1.84 shows an effect size ranging from medium to high. Oddly, the mean for item 21 dropped from 1.59 to 1.37. Since the p-value was 0.163 the difference doesn't have any significant relevance to the study. For the virtual condition, the same items (16, 18, 19 and 20) as the human condition showed significant changes in the means. Again, like the human condition the effect size ranged from medium to high. Unlike the human condition, a non-significant yet positive increase in the mean occurred for item 21 for the virtual condition group.

At the second step of analyses, an independent samples t-test was conducted to examine differences between the two mentorship modes. Here is where the question of which type of mentorship is more effective than the other can be appropriately tackled.

One would also be able to determine the specific capacities in which human mentorship is more effective than virtual mentorship and vice versa. Actual qualities and characteristics of mentorship were evaluated across both treatment groups. For example, such items included “My mentor challenged me to extend my abilities” and “My mentor was supportive an encouraging.” This 30-item scale was assessed item-by-item and as an overall scale, in which the scale was titled “Psychosocial.” In regard to this scale, human mentorship was overall more effective (p < .05, d = 1.37) with a large effect size. Only items 3 (4.17/4.21) and 15 (4.00/4.21) had a higher mean for the virtual treatment. Item 2 had a mean of 4.56 for both the human and virtual treatment. This suggest users on average felt the virtual mentor demonstrated professional integrity, demonstrated content expertise in the user’s area of need and encouraged the user to try new ways of behaving at their job. It also suggests that users felt that Lamar showed personal integrity on the same level as a human.

Interestingly enough, item 3 is approaching a significance difference with a p-value of .061, which suggests that users may prefer the virtual agent to human mentoring in the areas that they need help in. With a Chronbach’s Alpha of .975 the items for the Psychosocial scale showed a very high level of internal consistency. Also, for those that share a difference it is important to peruse the actual survey item and discern the type of variable that was assessed. Consider an item such as, “My mentor has conveyed empathy for the concerns and feelings I have discussed with him/her.”

One may not expect a student with virtual mentorship to score this item as highly, because of the affective and psychosocial implications of empathy. This notion should be applied to other items, particularly those that highlight respect and encouragement. Such constructs may have an inherently human element that a virtual mentor would fail to convey, and thus would have less bearing on students inculcated by a virtual mentor. Nonetheless, human mentorship was more effective with respect to the overall mentorship scale.

Graduate School Attitudinal Interest (Human vs. Virtual Post-Test Means) Independent Samples T-Test

Section 1 Items	**Human (μ, SD)**	**Virtual (μ, SD)**	**Mean difference**	**t-statistic**	**Sig. Value**
1. I am interested in pursuing a graduate degree in computing	(4.17, .985)	(4.11, 1.13)	.056	.157	.876
2. I am interested in pursuing a doctoral degree in computing	(4.00, 1.19)	(3.06, 1.82)	.941	1.82	.077
3. I feel confident I can get admitted into a graduate program	(4.39, .70)	(3.95, .97)	.442	1.58	.123
4. I feel confident I will do well as a graduate student	(4.33, .69)	(4.11, 1.05)	.228	.778	.442
Interest & Confidence Subscale (Items 1-4)	(4.22,0.74)	(3.86, .987)	.358	1.24	.22

Note: The Likert scale ranges from 0 (Strongly Disagree) to 5 (Strongly Agree)

*Indicates a statistically significant difference from the pre-test score at the p < .05 level.
** Indicates a difference that is approaching a statistically significant level

Graduate School Attitudinal Interest (Human vs. Virtual Post-Test Means) Subscale Reliability

Interest & Confidence Subscale (Items 1-4)	**Cronbach's Alpha**	**Number of Items**
	.785	4

Graduate School Funding Attitudinal Knowledge
(Human vs. Virtual Post-Test Means) Independent Samples T-Test

Section 2 Items Items	**Human (μ, SD)**	**Virtual (μ, SD)**	**Mean difference**	**t-statistic**	**Sig. Value**
5. I am knowledgeable about funding sources for graduate school	(3.94, .966)	(3.68, 1.29)	.257	.669	.508
6. I am knowledgeable about graduate fellowships	(3.94, .873)	(3.61, 1.20)	.333	.956	.346
7. I am familiar with many fellowship opportunities	(3.50, .99)	(3.06, 1.55)	.444	1.03	.312
8. I understand how to apply for a fellowship	(3.53, 1.33)	(3.31, 1.58)	.217	.428	.672
9. I am knowledgeable about assistantships	(3.61, 1.46)	(3.76, 1.25)	-0.154	-0.333	.741
10. I understand how to apply for an assistantship	(3.33, 1.50)	(3.40, 1.64)	-0.067	-0.122	.904
11. I know the difference between a fellowship and an assistantship	(3.61, 1.42)	(4.18, 1.55)	-0.57	-1.13	.268
12. I am familiar with many graduate school visitation opportunities	(3.56, .984)	(3.25, 1.34)	.306	.763	.451
13. I am knowledgeable about other African Americans who have a PhD in computing	(3.78, 1.26)	(3.18, 1.38)	.601	1.35	.187
14. I am familiar with organizations that I join that could provide me with info about pursuing a graduate degree in computing	(3.50, 1.20)	(3.35, 1.41)	.147	0.333	.741

Section 2 Items Items	**Human (μ, SD)**	**Virtual (μ, SD)**	**Mean difference**	**t-statistic**	**Sig. Value**
Funding Knowledge Subscale (Items 5-14)	(3.63, .942)	(3.40, 1.15)	0.23	0.66	.512
Note: The Likert scale ranges from 0 (Strongly Disagree) to 5 (Strongly Agree) *Indicates a statistically significant difference from the pre-test score at the p < .05 level. ** Indicates a difference that is approaching a statistically significant level					

Graduate School Funding Attitudinal Knowledge (Human vs. Virtual Post-Test Means) Subscale Reliability

Funding Knowledge Subscale (Items 5-14)	**Cronbach's Alpha**	**Number of Items**
	.913	10

Human Condition Graduate School Achievement Knowledge Independent Samples T-Test

Open Ended Items	**Human (μ, SD)**	**Virtual (μ, SD)**	**Mean difference**	**t-statistic**	**Sig. Value**
15. How many mentors do you have that are knowledgeable about attending graduate school in a computing discipline?	(2.28, 1.32)	(1.89, 1.85)	.383	.721	.476
16. How many fellowship opportunities do you know about?	(1.69, 1.47)	(1.53, 1.68)	.168	.324	.748
17. How many graduate school visitation events are you familiar with?	(1.83, 1.58)	(1.84, 1.98)	-.009	-.015	.988
18. What is a fellowship?	(0.647, 0.424)	(0.868, 0.327)	-.221	-1.74	.092
19. What is an assistantship?	(.824, .498)	(.605, .428)	.218	1.42	.166
20. What are the different types of assistantships?	(1.41, 1.18)	(1.05, 1.27)	.359	.878	.386
21. What career options does one have with a PhD in computing?	(1.94, 1.20)	(1.63, 1.30)	.310	.740	.464
Note: Items 15-17 are cumulative values. Items 18 and 19 are scaled values ranging from 0 to 1 (e.g. 0 = no clue, 0.5 = somewhat know, 1.0 = know). Items 20 and 21 are also cumulative values.					

Lastly, there were no significant differences between the virtual mentoring experience and the human mentoring experience. In all but five items (items 9, 10, and 11, 17, and 18) the average mean for the human mentoring was slightly higher than the virtual mentoring.

When asking about the participants' knowledge of assistantships (item 9), understanding of how to apply for an assistantship (item 10), knowledge of the differences between an assistantship and fellowship (item 11), knowledge of graduate school visitation events (item 17) and knowledge of what a fellowship was (item 18) the virtual treatment slightly outperformed the human treatment. Items 9, 10, 11 and 18 were questions that the virtual mentor had specific answers for. Again, these differences in the mean were not significant, thus not a single item had or even approached a significant difference in the means. A Chronbach's Alpha of 0.713 and 0.913 suggest an acceptable and strong internal consistency of the Funding Knowledge and Interest and Confidence subscales, respectively.

Considering there is pre and post-test data for each group in the experimental design, an analysis of covariance (which controls for pre-existing differences at the pre-test onset) is deemed appropriate for comparing experimental and control groups (Chen, Lien, Annetta & Lu, 2010). An analysis of covariance was not run because another independent samples t-test (which compared pre-test scores on the graduate funding scale) detected no significant pre-existing differences.

V. Discussion

The study set out to explore the use of embodied conversational agents as virtual mentors compared to current human-to-human mentoring. The population of the study was African American computer science majors at a historically Black college. The agent's purpose was to mentor the students on the pursuit of a graduate degree in computing. Success of this study could call for the need of additional studies that are longer in term, at different institutions on students with different majors, genders and ethnicities. The study sought to answer three primary questions:

1. How effective is organic, short-term, human-to-human mentoring in this environment?
2. How effective is short-term mentoring using an embodied conversational agent in this environment?
3. How effective was the virtual mentoring interaction compared to the human-to-human interaction in this environment?

The quantitative data gathered in the survey showed no significant difference between the virtual and human treatment in increasing student interest in attending graduate school, becoming admitted into a graduate program or doing well in a graduate program. When testing the participants' attitudinal knowledge of graduate school infrastructure, terminology and opportunities such as fellowships and assistantships, there was a significant difference in each of the ten questions. This was deducted due to mean differences for those ten questions ranging from -1.00 to -1.83. When asked to demonstrate knowledge they achieved during their experience, the results were consistent. There was a significant difference between their knowledge of the definitions for fellowship and assistantship and what various assistantship types existed after the human mentoring intervention. Overall, the qualitative data suggested human mentoring provided a significant difference in the knowledge the participants had about graduate school.

One observation about the data collected for the interest and confidence subscale (items 1-4) was high overall interest in attending graduate school and doctoral program. In an effort to study the effects of both the human and virtual treatment on those who were not already convinced that they wanted to pursue a doctoral degree in computing, those participants were removed from the sample. These participants indicated that they "strongly agree" that they were interested in pursuing a doctoral degree in computing. Strongly Agree was determined as the cutoff point. Since only one graduate from this department successfully entered a doctoral program in computing in the last two years, it would be less than likely that an upperclassman who had reservations in their interest about graduate school would actually apply, get accepted and decide to attend. For the human treatment group, a total of six participants rated "Strongly Agree" to having an interest in a doctoral program in computing and were omitted from the additional analysis. Of those six participants 4 participate in a sponsored research program at the institution and one participant had already applied to at least one doctoral program for the Fall 2013. This left 11 participants from the human treatment group. When asked about their knowledge of funding (Funding Knowledge subscale) the mean of these increased from 2.29 to 3.50 on a scale of 1 through 5.

The quantitative data collected with the pre and post-surveys show no significant difference in the responses for increasing student interest in graduate school, becoming admitted in a graduate program and doing well in a graduate program.

Oddly, there was a significant difference (0.027) when asked about the interest in pursuing a doctoral degree in computing; however, due to an unusually low mean in the pre-test compared to the same question in the other group, this difference was not conclusive. Overall, based on the numbers the virtual agent did not change student's interest since they were already interested.

When testing the students' attitudinal knowledge of graduate school infrastructure, terminology and opportunities, similar to the human mentoring, there was a significant difference in almost all of the items (nine out of a possible ten). When asked to demonstrate knowledge they learned from interacting with the mentor, the results were very similar to those of the human mentoring treatment. There was a significant difference between their knowledge of the definitions for fellowship and assistantship and what various assistantship types existed. Overall, like the human mentoring, the qualitative data suggested a significant difference in the knowledge the participants knew about graduate school.

Similar to the human mentoring treatment, a question could be asked of the impact of the virtual mentoring treatment for those students who are not already convinced that they would want to pursue a doctoral degree in computing. To answer this question, the data for participants who indicated that they "strongly agreed" to have an interest in a doctoral program were removed from the subgroup. Unfortunately, three of the participants of the virtual treatment group did not answer this question item on either the pre or post survey so their data was removed as well. Of the remaining 12 participants in the subgroup the mean increased from 1.98 to 3.41 when asked the questions on the Funding Knowledge subscale. This increase of 1.43 is much larger than the 0.38 difference recorded from the entire virtual mentoring group.

Overall, the majority of the survey elements showed no significant difference when using the virtual mentor compared to the human mentor, excluding the survey items that evaluated various psychosocial mentoring functions.

In those 18 questions, there was a significant difference after the mentoring experience for 15 of the 18 questions. For human mentoring participants, the mean values for the post survey responses ranged from a 3.85 to a 4.47, suggesting that the participants felt the human mentor had a positive effect in terms of mentoring functions.

The absence of a significant difference in the other questions suggests the career functions can be obtained using an embodied conversational agent.

The findings of this research provide multiple directions to expand. The following goals contain the primary targets for future studies into mentorship using embodied conversational agents:

1. The content stored in the virtual mentor should be expanded to include other areas of expertise other than career options and funding opportunities.
2. Information about particular graduate schools such as diversity, ranking, size, location, minimum GPA, minimum GRE scores, and application deadlines should be added to the agent.
3. A database of graduate school fellowships, description of current research areas and graduate school rankings can be merged with the virtual agent.
4. Custom responses from the agent should be delivered to the user based on user preferences and attributes such as GPA, REU experience, major,
5. Functionality of the agent should be expanded to enhance the delivery of psychosocial mentoring functions to users.
6. The study should be expanded to include other colleges and universities.
7. The long-term effects of using the agent should be measured in addition to the short-term effects.
8. The accuracy of VM1 should continue to be measure as the corpus of mentorship content and the number of interactions with the system increases.
9. More data should be collected on the current career interest of the participants to see how to adapt the system to provide more beneficial career advice.

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There were several limitations to this research that should be noted. First, the knowledge utilized by the virtual mentor only consisted of two areas, career options and funding opportunities. Second, the study was conducted at one school. Third, that school was an all-male institution and the study didn't show how effective virtual mentorship would be with African American females. Lastly, the school chosen for the study only offers bachelor's degrees and no graduate degrees.

This research was successful in justifying the need for more research being conducted on the option of offering virtual mentoring in addition to human mentorship for African American computer science students. In addition, the impact of human mentorship was confirmed as well. Findings from the study suggest the expansion of this research to include other ethnicities as well as other STEM disciplines. It is the opinion of the author that this manuscript adds virtual mentorship as an effective tool when used independent of or in collaboration with human mentoring in the effort to broaden participation in STEM fields. Thus, the mentoring constellation of the user will include virtual mentors in addition to human mentors.

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