Toward a National Agenda for Broadening Participation of African Americans in Engineering & Computer Science: A Methodological Overview of Phase II

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Abstract— This "work in progress" showcases the methodological processes underway in Phase II of a three-part study. In its entirety, the study aims to (1) critically assess and evaluate the current research-to-practice cycle as it relates to participation and success of African Americans in engineering and computer science, and (2) set a national agenda for broadening the participation of African Americans in these two fields. Phase II of this study consists of semi-structured interviews with approximately 60 subject-matter experts from the fields of K-12 education, undergraduate education, graduate education, and the engineering and computing workforce. This paper discusses the following processes: a) participant recruitment, screening, and selection, as well as, b) protocol development and piloting. Insights about our methodological approaches might be useful to others developing research designs intended to capture the perspectives of various stakeholders associated with similarly complex and multifaceted issues.

Keywords— instrumental case study; methods; research agenda; participation; engineering; computer science; African Americans

I. INTRODUCTION

Addressing a nationwide issue such as broadening participation of in engineering and computer science is a complex and multifaceted exploration that requires strategic planning and preparation. This paper provides a brief update on the progress of a federally funded, three-phase study focused on this issue, with a particular emphasis on the methodological details of Phase II. Because engineering education is a relatively young field that typically borrows methods from other fields, few studies offer transparency around approaches to sampling (particularly participant recruitment and selection) and protocol development--especially in qualitative studies. Accordingly, we are writing this paper to contribute to the body of literature focused on qualitative research methods in engineering education. The remainder of this paper includes an overview of the whole project, highlights of our progress in the first two phases, and detailed insights about the methods associated with the second of three phases. Our aim is to share this concrete example of how a study was designed to garner the perspectives of various stakeholder associated with a multifaceted issue such as broadening participation with the expectation that it will be insightful to others taking a scholarly approach to addressing similarly-complex challenges.

II. OVERVIEW OF LARGER PROJECT

The ultimate goal of the larger project is to develop a national agenda for broadening the participation of African Americans in engineering and computer science that is informed by existing scholarship, and the insights of various stakeholders. This study is motivated by the decline we have seen in the proportion of African Americans graduating with engineering degrees and entering the workforce--despite large investments, national agendas, research on this topic, and the efforts of many groups of people at various levels [1, 2, 3]. Parallel disparities exist in computer science [2]. Since many computer science programs are housed in colleges of engineering, we saw the co-existence of these two disciplines as the impetus for our opportunity to study the issue of broadening participation for this demographic in both fields.

Some engineering education researchers, business leaders, and government officials have suggested "*systematic research of how we educate engineers must be the path* by which we transform from episodic cycles of educational reform and move to continuous, long-lasting improvements in our education system" [4, p. 259, emphasis added]. Similarly, the *Innovation Cycle of Educational Practice and Research* depicts a cyclical and symbiotic relationship between educational research and practice [5]. However, the aforementioned disparity suggests that there is a gap between research and practice with regard to broadening participation of certain underrepresented groups in engineering and computer science (CS). As part of the larger study, we argue that now is the time to take a step back, investigate what existing literature says about this topic, recalibrate our strategy for addressing this persistent problem, and figure out what is pushing students away from engineering and CS.

Thus, the goal of the larger project is to develop a conceptual model that more accurately depicts the relationship between research and practice in the context of broadening participation, and to outline a national agenda for coordinating the efforts of different stakeholders committed to this effort, particularly as it relates to African Americans in engineering

and CS. To achieve this goal, the larger project is organized into three phases designed to gather knowledge about the association between research and practice though incorporating existing literature and the perspectives of scholars engaged in this topic. Phase I includes conducting a systematic literature review (SLR) [6, 7] and Phase II includes conducting interviews with researchers and practitioners engaged in this topic across four segments (i.e., K-12, undergraduate education, graduate education, and the workforce). The project concludes with a Delphi study [8] during Phase III. It will lead to a consensus on the key issues, gaps in our understanding, significant questions, and breakdowns in the *Innovation Cycle of Educational Practice and Research* [5]. *An Innovation Cycle for Broadening Participation* will ultimately capture the national agenda that will stem from this phase.

To date, Phases I and II are well-underway. The overarching research question guiding the first phase of the study is: *What is the current state of research and practice on broadening the participation of African Americans in engineering & computer science, according to scholarly literature and national reports?* With this in mind, Phase I has included the development of a systematic literature map [9], an umbrella review of national reports related to this topic [10], and a series of systematic literature reviews on a variety of relevant topics are also in progress. Other publications include detailed insights about each of these activities [10, 11, 12], and other publications are forthcoming. The remainder of this paper is on Phase II.

III. OVERVIEW OF PHASE II: RESEARCH QUESTION AND DESIGN

A. Research Question

The following research question guides the last two phases of the study: *How should the* Innovation Cycle of Educational Practice and Research *be modified to reflect the current state of the literature and a meaningful agenda for broadening participation of African Americans in engineering & computer science?* The purpose of this paper to showcase the methodological processes underway in Phase II and provide an overview of how intentional dialogue with expert stakeholders will contribute to advancing our understanding of the disconnect between research and practice, and ultimately work to mitigate and close the gaps that hinder participation of African Americans in engineering and computer science. Phase II uses Instrumental Case Study (ICS) methodology to gain primary source insight on the trends of African American participation in engineering and computer science. At this stage in the research process, the participant pool and interview protocols are being developed.

B. Methodology

This study uses an Instrumental Case Study methodology to gain insight on expert researcher and practitioners' understanding of, and efforts towards, broadening the participation of African Americans in engineering and computer science. Case study is a methodological means for studying the particularities and complexities of a single case in order to understand events, circumstances, or phenomenon [13, 14]. While there are multiple types of case studies, an Instrumental Case Study provides "insight into an issue or to redress a generalization" [13, p. xi]. Instead of focusing on a particular "case", an ICS can examine particular policies and practices and how those policies and practices connect with and influence the experiences of particular actors, groups, or communities [14].

Through nearly 60 semi-structured interviews with expert researchers and practitioners in the fields of engineering, computer science, and Science, Technology, Engineering, and Mathematics (STEM) broadly, and from K-12, undergraduate, graduate, and workforce backgrounds, this study aims to better understand what policies and practices influence the participation of African Americans pursuing and maintaining academic and professional experiences in engineering and computer science. The data gathered from these interviews will lead to identifying and closing the gaps in the research to practice cycle towards recruiting, retaining, and supporting African Americans in the focus area fields of this study, ultimately closing the gaps in representation. The remaining sections will include additional insights about participant selection and protocol development.

C. Participant Selection Process

In qualitative research, purposeful sampling is a method used to identify and select information-rich cases related to the phenomenon of interest [15]. For this study, potential research participants were targeted through purposeful sampling because they are especially knowledgeable about the area of study and are able to accurately and insightfully speak on the particular matter. In addition to experience and expertise, research participants targeted through purposeful sampling are identified because they have the availability, willingness, and interest to contribute to the study and are able to make reflective contributions of knowledge and experience to the data [15]. For this study, in an effort to facilitate maximum variation, the initial potential participant lists were developed based on personal contacts, existing literature, and recommendations from advisory board members. The research team, identified colleagues in the fields of engineering and computer science, particularly targeting those whose work is centered on underrepresented groups.

Once the initial list of nearly 100 potential research participants was formulated, each individual on the list was vetted to assess and determine professional **focus area** (engineering, computer science, STEM), professional **segment** of work (Informal Education/K-12, Undergraduate Education, Graduate Education, and Workforce), as well as whether their **backgrounds** were aligned in either research (R), practice (P), or a combination of both (B). This vetting was conducted via internet searches of their public professional profiles. The categories in which potential participants were identified as and placed by researchers will be cross-checked with the

individual upon agreement to participate, and any necessary adjustments to identification will be made. Additionally, it should be noted that this initial list will continue to expand as gaps in representation are identified and more individuals with professional profiles and experiences that relate to this study are considered.

Each potential participant will receive an invitation to participate in the study as well as a participant profile form that asks questions regarding their professional work in computer science and engineering, their understanding of representation disparities in the fields, their attitudes towards broadening participation of African Americans in engineering and computer science, and their interest and availability for participating in this study. In addition to the participant profile form, each potential participant and other stakeholders will also receive a nomination form enabling them to recommend participation of other individuals whom they think could productively contribute to the research. This is an example of a different type of participant recruitment method--snowball sampling. Snowball sampling derives from the researcher asking current research participants to recommend other individuals to participate in the study [16]. The use of snowball sampling for this study allows us as researchers to expand upon our own professional networks and tap into networks of knowledge that might otherwise not have been reached. Those individuals, recruited either through purposeful or snowball sampling, who indicate an interest in and commitment to participate in the study will be considered for the final research participant pool. The final pool of research participants will be based on accurate representation distribution across fields, participants' alignment with study, and participants' availability and commitment to participate throughout the duration of study.

In this phase of the study, a research participant database is being compiled to ensure that participants are able to provide robust and widely experienced information and insight towards establishing meaningful research, practice, and policy agendas for broadening participation of African Americans in engineering and computer science. Intentional effort is being taken to garner a representative distribution of participants from each **focus area** (Engineering, Computer Science, STEM) and **segment** (Informal Education/K-12, Undergraduate Education, Graduate Education, and Workforce), as well as those with backgrounds in either research (R), practice (P), or a combination of both (B). Please note that these participant designations are fluid, meaning participants' focus areas, segments, or background designations are transferable across multiple sectors depending on how they identify their work practices and areas of expertise. An example of the participant database matrix is represented in Table 1 below.

Collectively, the research participant pool will offer a saturated knowledge of the research area and provide a collection of recommendations that are based in expert knowledge and practice, leading to well-informed policy and practice recommendations and agendas that are ultimately derived from the study.

TABLE 1: RESEARCH PARTICIPANT MATRIX EXAMPLE

Table 1. Research Participant Matrix Example					
		SEGMENT			
		Informal Education, K-12	Undergraduate Education	Graduate Education	Workforce
FOCUS AREA	**ENGINEERING**				Sample Participant A (P)
	COMPUTER SCIENCE		Sample Participant B (R)	Sample Participant B (R)	
	ENGINEERING & COMPUTER SCIENCE	Sample Participant C (P)			
	STEM		Sample Participant D (B)	Sample Participant D (B)	Sample Participant D (R)

IV. DATA COLLECTION

Again, Phase II of this study is guided by the following research question: *How should the Innovation Cycle of Educational Practice and Research be modified to reflect the current state of the literature and a meaningful agenda for broadening participation of African Americans in engineering & computer science?*

To answer this research question and collect data for Phase II, semi-structured interviews will be conducted with at least 60 subject matter experts of various backgrounds in engineering and computer science. These interviews allow us to investigate the beliefs, insights, experiences, and recommendations of various stakeholders involved in broadening participation efforts. In this study, 'stakeholders' is used to include any person with a professional interest and prior experience in broadening the participation of African Americans in engineering and computer science. The interviews will take the form of a traditional social science interview [17]. The semi-structured interview protocol includes open-ended questions and probes that may vary depending on the stakeholder's experience with broadening participation. We are using semi-structured interviews to examine how stakeholders explain their experiences working towards this effort and rationalize the lack of national progress. Interview guides are being informed by the findings from the systematic literature reviews completed in Phase I, and the Innovation Cycle of Education Practice and Research [5] will inform our questions; we present a sample selection of interview questions from the study in Table 2.

A. Piloting

To date, the first complete draft of the interview protocol is in the final stage of development. Pilot interviews will be conducted with at least one person from each professional segment, totaling in 4-8 pilot interviews. Once a complete interview protocol is established, the research team will begin holding pilot interviews with trusted and accessible colleagues

in the field. These colleagues who will participate in the pilot process will be able and willing to provide critical feedback that can be used to strengthen the interview protocol and move it to its final development stage. Pilot studies are undertaken as a small-scale test to ensure that the methodology of the larger study is effective and work in practice [18].

TABLE 2: SELECTED INTERVIEW QUESTIONS

Table 2. Selected Interview Questions
• Describe the role you play in broadening the participation of African Americans in engineering and/or computer science.
• Please describe some of the programs and or interventions that you have worked with that are aimed at supporting Africans Americans in engineering and/or computer science? In what ways were they successful? What were some challenges?
• In what ways has educational research contributed to solving this problem? In what ways has it not? What are examples of topics that could benefit from additional research?
• Across to the American Society of Engineering Education, the representation of African Americans in engineering has decreased. Based on their understanding of this issue, what would you attribute this lack of progress to?
• Reflecting on the past decade, what are some of the more effective efforts that you have seen in encouraging the participation of African Americans in engineering and computer science that should be replicated? (Both nationally and locally)
○ As a community, what are we not doing that we should be doing?
○ What are some new practices that could be implemented?
• What can be done to potentially improve the relationship between research and practice in this context?

During the pilot interviews, the interviewer and interviewee will complete the interview protocol as-is in its entirety. Upon completion of the pilot interview, the participant will provide feedback guided by the following questions:

1. Did the questions asked in the interview allow for the interviewee to share accurate reflection of knowledge of local and national trends of African Americans' participation in engineering and computer science?
2. Did the questions allow interviewee to clearly articulate an understanding of how research and practice are/can be used to broaden participation of African Americans in the fields?
3. Did the interview protocol ask the questions necessary to establish a broad data pool to establish recommendations towards broadening the participation of African Americans in engineering and computer science?
4. Are there any other questions that were not asked that could prove useful to this study?
5. Were there any questions asked that are irrelevant to this study?
6. As a respected expert in the field, is there anything else we should consider as we finalize the interview protocol?

The feedback gathered through the pilot interview debriefs will inform improvements towards the development of the final interview protocol to be used during the formal study.

B. Data Collection and Analysis

Once the interview protocol is in the final form to be used as the data collection tool for Phase II, interviews will take place with research participants. Interviews will take place in person, via telephone, or by videoconference. Upon completion of all interviews, the interviews will be transcribed, analyzed, and coded.

The interview data from this study will be analyzed using the general approach of qualitative analysis presented by Miles, Huberman, and Saldaña [8]. These researchers describe qualitative analysis as three concurrent flows of activity: (1) data reduction or condensation, (2) data display, and (3) drawing and verifying conclusions. **Data reduction** will primarily consist of a structural coding and pattern coding and will be completed for each within-case sub-unit. First, interview transcripts and documents will be sorted using structural codes from the Innovation Cycle of Educational Practice and Research: (1) educational practice, (2) questions & ideas, (3) educational research, and (4) answers & insights. Next, we will generate pattern codes to group the text within the structural codes into meaningful categories (i.e., themes). **Data display** will primarily consist of modifying the Innovation Cycle of Educational Practice and Research [5] to represent the perspective of the stakeholders in each segment. **Drawing and verifying conclusions** will primarily consist of noting patterns, explanations, and propositions from the start of data collection, commencing only at the conclusion of the project. To facilitate this process, in addition to the analysis methods previously mentioned, we will use methods such as the following: collecting typed field notes; leveraging data triangulation; building a logical chain of evidence; using member checking; and making contrasts and comparisons across segments. (If participants' responses include references to literature not included in the systematic literature review, the review will be revised to incorporate the insights.)

V. SUMMARY

As part of advancing the scholarship on qualitative research methods in engineering education, this "work in progress" provides: 1) an overview of a three-phased study focused on the broadening participation of African Americans in engineering and computer science; and 2) methodological details about the sampling and protocol development. Our hope is that the research design surrounding this study will serve as a model for others interested in addressing other complex, multifaceted challenges in engineering and computer science education. Furthermore, it is our hope that the results of the larger study will inform practice, research, programmatic, and funding decisions at local and national levels. Ultimately, the results of this completed project will be disseminated broadly so that researchers, practitioners, policy makers, and organizations can incorporate the findings into their local and national efforts to broaden the participation of African Americans in engineering and computer science.

References

[1] M. T. Gibbons, "Engineering by the numbers," American Society of Engineering Education, Washington, DC, 2009.

[2] B. L. Yoder, "Engineering by the numbers." American Society for Engineering Education, 2015.

[3] M. Nelson and K. Reid, "NSBE 2025: the strategic plan to dramatically change the face of engineering by 2025." National Society for Black Engineers, 2016

[4] The Research Agenda for the New Discipline of Engineering Education. (2006). Journal of Engineering Education, 95(4), 259-261

[5] L. Jamieson and J. Lohmann, "Creating a Culture for Scholarly and Systematic Innovation in Engineering Education: Ensuring U.S. Engineering has the Right People with the Right Talent for the Global Society," Online for free at http://www.asee.org/about/board/committees/CCSSIE/, 2010.

[6] M. Petticrew and H. Roberts, Systematic reviews in the social sciences: A practical guide: John Wiley & Sons, 2008.

[7] M. Borrego, M. J. Foster, and J. E. Froyd, "Systematic literature reviews in engineering education and other developing interdisciplinary fields," Journal of Engineering Education, vol. 103, pp. 45-76, 2014.

[8] M. B. Miles, A. M. Huberman, and J. Saldana, Qualitative data analysis: A methods sourcebook, 3 ed. Thousand Oaks, CA: Sage, 2014.

[9] Grant, M. J., & Booth, A. (2009). A typology of reviews: An analysis of 14 review types and associated methodologies. Health Information and Libraries Journal, 26(2), 91–108. https://doi.org/10.1111/j.1471-1842.2009.00848.x

[10] Holloman, T. , Lee, W.C., London, J., Halkiyo, A., Jew, G., Watford, B. (2018). A Historical and Policy Perspective on Broadening Participation in STEM: Insight from National Reports (1974-2016). Paper presented at the 2018 Collaborative Network for Engineering and Computing Diversity (CoNECD) Conference, Arlington, VA.

[11] C. M. L. Phillips, J.S. London, W. C. Lee, A. S. Van Epps, and B.A. Watford, Reflections on the messiness of initiating a systematic literature review on broadening participation in engineering and computer science.," in IEEE Educational Society Frontiers in Education, FIE 2017, Indianapolis, IN, USA, October 18-21, 2017.

[12] London, J., Lee, W.C., Watford, B., Holloman, T., Halkiyo, A., Jew, G., Hawkins Ash, C. D., Phillips, C. (In Review, 2018). Toward a National Agenda for Broadening Participation of African Americans in Engineering and Computer Science: Insights from Year One. Paper submitted to the 2018 American Society for Engineering Education Annual Conference, Salt Lake City, UT.

[13] R. Stake, *The Art of Case Study Research*. Thousand Oaks, CA: Sage Publications, 1995

[14] C. Compton-Lilly, "Case studies," in *Reviewing Qualitative Research,* A.A. Trainor & E. Graue, Eds., Reviewing. New York: Routledge, 2005, pp. 54-65

[15] L. Palinkas, S.Horwitz, C. Green, J. Wisdom, N. Duan, & K. Hoagwood. "Purposeful sampling for qualitative data collection and analysis in mixed method implementation research," *Administration and Policy in Mental Health*, 42(5), 2015, pp. 533–544.

[16] J. Creswell. Educational Research: Planning, Conducting, and Evaluating Quantitative and Qualitative Research (2nd ed.). Upper Saddle River, NJ: Pearson/Merrill/Prentice Hall, 1995.

[17] M. Q. Patton, Qualitative research and evaluation methods, 4th ed. Thousand Oaks, CA: Sage, 2015

[18] Kim, Y. (2010). The pilot study in qualitative inquiry: Identifying issues and learning lessons for culturally competent research. *Qualitative Social Work, 10(2), 190-206.* Retrieved from: http://journals.sagepub.com.ezproxy1.lib.asu.edu/doi/pdf/10.1177/14733 25010362001