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Critical Inquiry into Urban African American Students' Perceptions of Engineering

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Critical Inquiry into Urban African-American Students' Perceptions of Engineering

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Abstract

The purpose of this study was to critically examine the perceptions that African-American high school students have towards engineering. A qualitative research design using criterion sampling and snowballing was used to select seven African-American students from urban high schools to participate in the research. Semi-structured interviews were used to collect data from participants attending urban high schools on the east and west coast. Using Critical Race Theory (CRT) as the theoretical framework, the study was able to produce "emergent themes" from collected data. Findings from this study will help researchers understand how African-American students may perceive the field of engineering.

Introduction

As the global nature of our economy expands, Americans are increasingly cognizant of the economic impact of the global marketplace. Over the next twenty years, the most valuable resource of any country will be its human and intellectual capital (National Academy of Engineering, 2004). The inequality of African-Americans in science and technology introduces vital concerns for equal opportunity and the capacity of American education to produce an ample number of future scientists and engineers. In comparison to many of the non-technical fields, careers in engineering and technology have been less diverse (American Association for the Advancement of Science, 1998). This statistic foreshadows a perilous future for American minorities seeking careers in technical fields.

To skillfully adapt to an ever-changing economy in a capitalist society it is very important that African-Americans become more technologically competent in coming years (Johnson & Watson, 2004). This lack directly impacts the number of African-Americans who might become future participants in engineering and technology-based fields. This lack also has huge implications for the economic and social vitality of the nation as we continue to compete in global marketplaces (Maton & Hrabowski, 2004).

The challenges of attracting African-Americans to technical fields like engineering are compounded by problems that appear to be associated with American school systems (Wharton, 1992). Some writers believe that present achievement gaps on standardized tests between black and white students are artifacts of racial stereotypes. For example, Gordon (2003) postulated that historical issues such as slavery, institutional racism and discrimination have led to an unequal distribution of funds and resources that

contributes significantly to today's disparities between Caucasian and African-American students.

Modern learning theories and recent cognitive research have made important strides in understanding how students learn within the design of effective instruction (Schell & Schell, 2008). Unfortunately, these advancements have not proven helpful to a diverse body of students (Flores, Oates, & Weishew, 1996). This is particularly true for math and science courses (Singham, 2003). Obviously these areas are cornerstones for the discipline of engineering, areas where African-American students perform well below their Caucasian counterparts on standardized exams (Singham, 2003; Wicklein, 2006). For the field of engineering, attracting more African-Americans is further complicated by a generally negative perception of engineering held by many students (NAE, 2008).

By juxtaposing the reality of the achievement gap with the negative perceptions held by many students toward engineering, researchers can start to pinpoint reasons as to why more African-Americans are not pursuing careers in engineering. By examining the reasons for the achievement gap in math and science between African-American and Caucasian students, while seeking to understand the reasons for negative perceptions among many high school students toward engineering may engender some answers to these important questions.

Statement of the Problem

To ascertain the problem of achievement disparity, Carter (2005) outlined key challenges including: (a) undiversified teachers instructing an increasingly diversified student population, (b) instructional practices that are culturally unresponsive to the needs of a diversified population, and (c) over reliance on abstract mathematical and science

instructional practices. To address these challenges teachers at the secondary and post-secondary levels may need to make significant changes in how and what they teach (Lipman, 1995; Ladson-Billings, 1995a). More specifically, there may be a need for a paradigm shift from the approaches currently used to teach science and math (Tate, 1995). Students who are economically or otherwise socially disadvantaged may need opportunities to expand their knowledge base on which new math and science learning is derived (National Center for Education Statistics, 2001). As the nation looks to attract more African-American to engineering, the possible new paradigms may encompass a comprehensive approach that seeks to "reframe" the image of engineering (NAE, 2008). In addition, current teacher preparation, and professional development may be in need of change agents that reflect these perspectives.

We began this study by trying to understand more about the achievement and perception gaps for African-American high school students. It was our goal to work collaboratively with selected informants as we sought to understand the realities of achievement and probable dissonances frequently experienced by African-American high school students towards engineering as a possible profession.

Purpose of the Study

The purpose of this study was to critically examine the perceptions that African-American students have in regards to engineering and the cornerstone courses associated with the field. Seven African-American high school students were purposively selected to participate in this research. We believe that the findings of this study will help us understand how some African-American students perceive the field of engineering as a

potential career. Further we seek to explore the impact that cornerstone engineering courses may have on student's perceptions.

Research Questions

The research questions that guided this study were:

1. What do African-American high school students identify as factors that influence their perceptions of engineering?

2. What skill and ability areas do African-American students perceive are necessary to pursue a career in engineering?

3. How do African-American students relate to, define and describe persons going into the field of engineering?

Theoretical Framework

In an effort to effectively structure data collection efforts and develop a suitable research design a theoretical perspective is required (deMarrais, 2004). deMarrais argues that theoretical frameworks are bounded by a set of assumptions, which inform how a study is conceived, designed and carried out. For the purpose of this study, researchers used the Critical Race Theory (CRT) as a guiding framework. CRT is not only a theory that acknowledges social injustice and oppressive practices; it also helps to illustrate the relationship of power and culture thereby inciting awareness among the people of critical proportions (Crenshaw, 1995).

According to Matsuda et al. (1993), there are six unifying themes that define the movement. The essential elements of CRT are: (a) recognition that racism is endemic, (b) expressions of skepticism toward legal claims of neutrality, objectivity, colorblindness, and meritocracy, (c) challenge to ahistoricism and a contextual analysis of the law, (d)

recognition of the experiential knowledge of people of color, (e) interdisciplinary and (f) seek the elimination of racial oppression. This critical perspective has widely been used as an instrument of critique and a framework for examining legal issues of political, economic, and social inequality (Stovall, 2006). Recently there has been a burgeoning interest in using CRT as a tool of critique and analysis for K-12 education research (Lynn & Parker, 2006). There is a litany of literature, which argues for the use of CRT as a palpable theoretical construct to ascertain issues of social justice in the classroom (Dixon & Rousseau, 2005; Lynn & Parker, 2006; and Stovall, 2006). Using CRT to thoroughly critique these understandings will help form an understanding of the impact that a participant's culture has on their worldview (Crotty, 1998). This "worldview" that researchers seek to extricate from participants may offer partial solutions to the educational achievement gaps, and generally poor perception of engineering among African-American youth

Methodology

Hatch (2002) proffers that the purpose of critical inquiry is to raise a level of consciousness of the oppressed. This "transformative" theoretical framework seeks to provide communities with a raised consciousness that leads to social change through dialogue between researcher and participants. For its part, action research methodology is a methodology that seeks to move people towards social justice by integrating different forms of information (Conde-Frazier, 2006). For these reasons, action research is viewed as an ideal methodology to align with CRT.

For the purpose of this study action research methodology will be described by the researchers as participatory action research (PAR) (Avison et al., 1999). By providing

a cyclical and dynamic means to implement changes in practice, PAR supports the researcher and the practitioner in merging experiential and intuitive knowledge with academic and theoretical constructs (Conde-Frazier, 2006). Furthermore, the PAR process will enable the researcher and the practitioner to integrate research findings into practice in a meaningful way. In essence, PAR focuses on the lived experience of people and uses this knowledge in an effort to better understand the problem before and after proposing any solutions. In a battle for equality and social change, PAR moves us toward palpable solutions by integrating different forms of information (Conde-Frazier, 2006).

Data Gathering

Data collection procedures for this study consisted of audio-recorded semi-structured interviews which were transcribed using the services of a professional transcriber. Semi-structured interview techniques were used because we sought to gain in-depth knowledge into the perceptions and achievement disparity of the participants (deMarrais, 2004). As primary investigators for the study we acted as the main instrument of data collection. It is recommended that researchers develop interview guides, survey questions and other material with the assistance of a qualitative research consultant (Creswell, 1998). To verify the validity of instruments' ability to measure the desired constructs a qualitative expert was solicited and employed. The qualitative expert was influential in the construction of the semi-structured interview guide and in validating the responses of the participants. In this particular study, the primary researchers were concerned with the interpretation of the interviews; therefore we used an inter-rater reliability technique to test for reliability.

Interview sessions were conducted individually with each participant, at the convenience of the research participants. Participants were not promised any incentives or remuneration for their participation in the study. The first part of the interview session consisted of collecting demographic information on the participants through an unstructured interview process that encouraged the participants to talk about their background, and career aspirations. The second part of the interview session more closely followed the semi-structured interview guide developed by the researchers and qualitative expert. Follow-up questions were asked throughout the session to help clarify certain responses and offer participants an opportunity to elaborate on specific responses.

Analysis

For the purpose of this study the researchers employed analysis strategies as suggested by Creswell (1998). First, researchers performed a general review of all information collected while recording reflective notes. Next, codes were developed using the research questions that guided the study. Using those codes, frequency counts were used to determine themes that were recurrent in order to identify themes that were "emergent". Stemler (2001) contends that as a rule of thumb, frequency counts should be used to determine content of particular interest. In qualitative research, a summative content analysis usually involves the counting of keywords, followed by the interpretation of the underlying context (Hsieh & Shannon, 2005). Following the aforementioned strategies, emergent themes were identified from the data. These themes were used within the narrative in an effort to develop a comprehensive picture of the participants' responses. Within the narrative, quotes taken from the transcribed notes

were embedded to validate the themes described in order to provide readers with a rich, thick description of the emergent themes.

Validity and Verification

Creswell (1998) suggests that qualitative researchers look toward confirmability in lieu of objectivity to help establish the value of data. It is recommended that researchers employ at least two of the eight procedures that Creswell provides. For verification purposes of this study, the researchers engaged in procedures of providing rich, thick descriptions of participants' responses and a peer review of the responses (Creswell). These were used to validate emergent themes that formed from the study. Two independent analyses of the transcribed data were conducted by the primary researchers for this study. Emergent themes were verified only once consensus was reached among the researchers regarding these themes. In providing a rich, thick description of the emergent themes, quotes were used to help paint a picture and provide "good data" (Richards & Morse, 2002). Based on the procedures described, readers can have confidence that the conclusions and themes that emerged from the study are in fact a reflection of the participant's responses.

Participant Selection

Criterion-based selection and snowballing techniques were used to select seven participants from urban high schools on the east and west coast (deMarrais, 2004). To provide regional and urban samples, participants were selected from an urban city in southern California and an urban city in Northern Georgia. Three African-American high school students were selected from the Southern California location and four African-American high school students from the Northern Georgia location.

The criteria for the participants were: (a) high school students and decedents of the African Diaspora living in the selected regions of the United States, (b) accessible to the researchers, and (c) urban residents on the east and west coast. Pseudonyms were created for each participant in an effort to protect the anonymity of the participants. Brief descriptions of all seven participants are provided below:

California Participant 1 (Female)

Andrea is an 11th grade student who attends a college preparatory school in California. Upon graduating from high school she aspires to become a genetic counselor. A genetic counselor is an individual who can help identify and interpret the risks of an inherited disorder, explain inheritance patterns, suggest testing, and lay out possible scenarios. She explained that she became interested in this field of study after receiving encouragement by a teacher in a biology course she had taken.

California Participant 2 (Female)

Angela is also an 11-grade student who attends the same college preparatory school as Andrea. She recently attended an engineer camp wherein she had the opportunity to gain some hands-on experiences and learn about principles of engineering through a robotics design challenge. Although she attended an engineering camp it was not clear if she had chosen engineering as a career choice.

California Participant 3 (Male)

Elijah is a ninth grade student who attends a Christian high school in California. His parents are very active in his educational pursuits and often keep him engaged in extracurricular learning activities outside of school. A week before the interview he attended an engineering seminar at a local university. He is very interested in the

mechanical arts and likes to fix things around the house. It was not clear as to whether or not he has made a firm decision to enter the engineering field.

Georgia Participant 4 (Male)

Kobe is a senior at an inner city high school in the state of Georgia. He dreams of playing in the NBA one day but also has aspirations to be a special education teacher. He has been particularly influenced by his relationship with his guidance counselor and credits this with his interest to "help people". At the time of the interview he was not interested with pursuing a career within the engineering field.

Georgia Participant 5 (Male)

Vick is a sophomore at an inner city high school in the state of Georgia. He expressed his interest in pursuing a career in football and sports medicine. He explained that he learned about the profession of sports medicine in a science class but could not articulate the steps that he would need to take to pursue this career. His knowledge about engineering and other technical fields was limited as was his interest in the field.

Georgia Participant 6 (Male)

Wesley is a senior at an inner city high school in the state of Georgia. He is currently interested in pursuing a career in engineering and/or architecture. He was particularly influenced by mechanical drawing classes that he took as a senior at the behest of one of his teachers. The participant expressed an interest in seeing how things are built and liked working with "machines and things like that".

Georgia Participant 7 (Male)

Smooth is a freshman at an inner city high school in the state of Georgia. Ever since he was little he has been interested in sports and expressed an interest to play in the

NBA. However, he noted that he may not make it to the professional level and stated that he wanted to be an engineer. His sister's boyfriend is an "engineer" who works with computers and security systems.

Research Ethics

Researchers conducting research in educational contexts will have to be conscious of ethical responsibilities when working with students and teachers. In the world of research, students represent a particular vulnerable participant due to their youth and subjugated roles in school systems (Hatch, 2002). It is the researcher's responsibility to ensure that students are informed on their rights and what their participation will entail. Minor assent and parental consent was obtained before students were allowed to participate in any phase of the study. IRB approval was obtained from the researcher's respective institution before beginning the study.

Findings

Emergent Themes

Using the analysis strategies described above, transcribed data was able to yield several "emergent themes" that helped characterize the participants. The identified themes are as follows: (a) support for what? (positive and negative), (b) highly competent in science and math, and (c) grasp of conceptions of engineering elements. The findings and emergent themes below have been provided with the intention of providing a summary of the participants' responses. Quotes are included throughout to help emphasize the emergent themes identified.

Emergent theme: Support for what? (positive and negative)

Of all of the respondents only one of them stated that their school influenced their perception of engineering, or decision to consider engineering as a profession. However, the students did state that their teacher and/or school were very influential in their decision to pursue a particular career. The lack of exposure to technical fields such as engineering is evident in the participants' responses. According to the study, support for pursuing engineering as a career usually came from the participants or their parents in the form of a desire to "build things". In accordance with other respondents who noted the lack of exposure to engineering within their school environment, Wesley stated his interest for engineering was self derived. He stated:

> I think it was more innate. I just came up with it. Like I see things and I'm just like, oh that's cool, that's something I want to look into and I was like, yeah this will be a good field for me since I like looking into things. I like looking in things like that. (Page 3, line 5, File 5)

Smooth, who was also interested in a career in engineering stated that his desire came from his curiosity of the field. In describing his affinity for engineering he stated:

> Well, I was curious about it. First what happened was when I played with remote controlled cars, I messed with the wires and stuff and then I've always-my dad don't live with me so I always had to put up ceiling fans and stuff. So I have to know how to use what wires. And I was watching some shows with buildings and how you can build different shapes and

> make them look like this. And I was just thinking about all the buildings they haven't built yet…… (Page 3, line 25-26; Page 4, lines 1-6, File 6)

Elijah stated that his motivation to pursue engineering as a career came from his mother. Elijah commented, "Yeah, my mom, she basically motivates me. She says since I like engineering she said I should keep it up and take it as a career so I could have something that I enjoy to go to work (to)." (Page 1, line 9-11, File 7) When asked of the exposure in her curriculum to engineering professions, Angela stated in her interview that, "… I don't really hear it talked about as a career choice as much as a doctor or lawyer, things like that. So not really, not especially." (Page 3, line 9-10, File 1)When asked to describe her lack of an introduction to black engineers in her school, Andrea commented,"…because it's not really mentioned. Like being in middle school, I went to an all black middle school but we didn't really go into full details. It wasn't like, yeah let's talk about black inventors." (Page 4, line 10-12, File 2)

Emergent theme: Have to be good at science and math.

This very succinct statement exemplified what the majority of the participants felt were the skills and ability area needed to be successful in engineering. Though not all of the participants identified math and science as vital skills needed for engineering it was readily apparent that students who had some conceptual understanding of the field felt that it was important to have skills and ability in these areas in order to be successful. Elijah, in describing the type of knowledge an engineer would need to be successful posited that:

> Basically engineers need to know math. Lots and lots of math because in order to build things, you need to know how it's going to work and what amounts of whatever you need to have that thing work. So math. (Page 1, line 14-16, File 7)

Wesley from Atlanta contributed to this emergent theme by identifying the traits that he felt a successful engineer would need including:

> …because math, you've got to know geometry or like use the computer like setting up screens and things. And also science like how things work or how like an electrical system will run through the computer, like how information goes through it. (Page 2, line 22-24, File 5)

Andrea, although admitting not knowing what an engineer was, affirmed this conclusion by claiming engineers had to have, "Science and math……. I guess that's basically it, English, writing, math, and science of course." (Page 3, line 19-22, File 2)Angela simply stated three words when asked about the skills and knowledge needed to pursue a career in engineering. She stated, "Math and science." (Page 3, line 7, File 1)Andrea also stated that engineering's emphasis on math was influential in her decision not to consider engineering as a career choice. She stated, "I don't want to be an engineer, that's just not me because also I'm not really a good math student. Maybe that's stereotypical that you have to be good in math to be an engineer, but I'm just not." (Page 3, line 28-30, File 2)

Emergent theme: Conception of engineering as a field

Student participants felt that overall the field of engineering was one that was very creative and that an engineer's job description encompassed "building" and/or

"fixing" things. When asked to define engineering, Vick from Georgia stated, "They learn how to build things, like parts for cars, computer parts and stuff like that." (Page 2, line 6-7, File 4) Elijah also stated that, "Engineering would be fixing things I guess. Just coming up with new ideas to fix things. Engineers, they basically they think of new ways to make something that's already existing better. And they basically fix things." (Page 4, line 5-6; Page 1, line 12-13, File 7) Consistent with the view of many of the participants, Kobe described the tasks of engineering as such,

> "I guess like, to me, to keep it basic I would say they more or less like try to fix certain problems, correct certain things, build certain things, …" (Page 2, line 15-16, File 3)

A majority of the participants felt that engineers overall had to be very creative to perform their job. When asked about the need to be creative in the engineering field, Smooth stated,

> "Well, I think to a certain extent yes because you want to come up with something else that has to do with wires and stuff or you want to add an adaption or something." (Page 3, line 14-16, File 6) Wesley concurred with the assertion that engineers have to be creative by stating:
>
> I think they (engineers) have to be pretty creative like say if an engineer is working on the computer, they could make a good system;…
>
> So they have to be creative to put things together and keep coming back to see what they've done and keep using their work. (Page 2, line 10-14, File 5)

Angela, in describing what an engineer would look like to her, ending her statement by saying, "Basically I think engineers are creative in a technical way." (Page 3, line 4-5, File 1) When describing the skills needed to becomes an engineer, Vick posited, "Yes, they're (engineers) creative in a lot of ways…Like building and that sort. Like creativity." (Page 3, line 4-5, File 4) When questioned about the need to be creative in the engineering field, Elijah stated, "Yeah, you don't necessarily need it but creativity can make a big part in engineering…" (Page 5, line 9-10, File 7)

Conclusions

True to the nature of action research, researchers worked collaboratively with participants in order to address issues that seem to thwart math, and science education of African-American high school students. A secondary intention was to identify the negative perceptions gap held by the many African-American students toward engineering. To properly address these issues it was important to refer back to the research questions guiding this study. The research questions were developed as a guiding framework for researchers looking to critically examine the general realities of African-American high school students' perception of engineering and its related principles. When referring back to the research questions, there are many conclusions that can be drawn from this critical inquiry into urban African-American students' perception of engineering.

Research question one sought to identify what African-American high school students felt were factors that influenced their perception of engineering. Previous research has shown that the factors that influence the decision of African-American

students to pursue a certain career usually come from the home, school, and community (Fisher & Griggs, 1995). This study concurred with this assertion, noting that several of the participants credited a teacher and/or counselor for their interest in a particular field. With this said it was a bit disconcerting that the study only revealed one participant who identified their teachers or school environment as providing adequate exposure to engineering, thus preventing the participants from making an informed decision regarding engineering as a career choice. The study showed that students' decision to pursue a career in engineering usually came from a parent's influence, an innate desire to "fix" things and/or the participants' curiosity of engineering. In addressing CRT, this theory implies that racism has contributed to manifestations of group advantage and expresses skepticism toward colorblindness (Dixson & Rousseau, 2005). The conclusions extrapolated from the study indicate a perpetuation of stereotyping for a field that is predominantly occupied by white, middle-age males (NAE, 2008).

Research question two sought to identify what African-American high school students perceived to be the skills and ability area needed to pursue a career in engineering. The study found that the majority of the participants identified skill and aptitude in science and math as the necessary skills and ability area needed to pursue a career in engineering. With African-American students performing consistently below Caucasian students in the areas of math and science on standardized tests, this revelation may lend some answers as to why more African-American students do not pursue a career within the engineering disciplines. In addressing CRT, this theory is seen as interdisciplinary and many of the themes unifying the theory transcend different disciplines (Dixson & Rousseau, 2005). The historical shortcomings of African-

Americans in the math and science disciplines speak to a greater issue of equal opportunity and cultural relevance while providing some insight into the reticence of African-American students to pursue careers with foundations that lie in the science and math disciplines. Another theme that this study revealed centered on the conception that African-American students held of engineering as a field.

Research question three sought to reveal how African-American high school students identify with engineering. Although many participants were not able to essentially define engineering, the participants were able to provide a description of the field. Participants generally identified engineering as a creative field that consisted of "fixing" and "building" things. Moreover, the conclusions drawn from this research question may seemingly be void of any CRT implications. However, upon closer examination of the study results, it is evident that the perceptions that African-American high school students developed toward engineering were not readily cultivated in school, home or in the participants' community/environment. This revelation in itself has cultural and racial implications, stemming from CRT's assertion that racism is endemic in American life, (Dixson & Rousseau, 2005) which indubitably impacts the way that African-American students view a field that they are not privy to and one that has been predominantly dominated by white males.

Implications and Discussion

This study strongly suggests that educators emphasize skills in math and science, a culturally-relevant pedagogical approach to teaching math and science principles in order to attract African-American students to pre-engineering programs. Our findings and a litany of supporting literature strongly suggests the incorporation of culturally-relevant

pedagogy when teaching math and science (Ladson-Billing, 1995b; Lipman, 1995; Tate, 1995 & Shujaa, 1995). Our study suggests that this is indeed a viable intervention. Ladson-Billings (1995b) proffered that culturally-relevant teaching must meet three criteria: (a) an ability to develop students academically, (b) willingness to nurture and support cultural competence, and (c) the development of a sociopolitical or critical consciousness (p. 483). Such an approach to math and science education may be pivotal in raising the achievement level of African-American students. Our study suggests that students who perceive the relevance of science and math courses have greater self efficacy in these areas which may contribute to greater achievement in these areas.

Results from this study went towards informing practice and future research endeavors with regards to barriers that may preclude African-American students from pursuing careers in engineering. The results of this study were used to formulate a formal mentorship program that sought to: (a) provide early exposure to an engineering experience, (b) psychological support for mentored students, (c) culturally-relevant engineering design challenges, and (d) a video depiction representing some facet of engineering. Additional details of the results from this intervention are available on line at: http://graduate.gradsch.uga.edu/etdarchive/summer2008/denson_cameron_d_200808_phd.pdf. The mentorship program developed served as the precipice for the quantitative dissertation study titled *Formal Mentorship Programs and its Impact on African-American Male High School Student's Perception of Engineering* (NCETE, 2008).

Based on the results of our study and existing professional literature additional research is desirable. Specifically, future studies should investigate viable ways of

exposing and educating African-American high school students to the possibilities of careers in engineering. We concur with Fisher and Griggs (1995) that means such as counseling, identifying role models, and mentorship programs are likely to be effective. Literature concerning ways to increase the participation of African-Americans in technical fields, such as engineering, must be expanded and should reflect empirical research in peer-reviewed journals. According to the Committee on Economic Development, a cultural change is needed to counteract the perceptions of engineering held by many African-American students (NAE, 2008). [1]

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