

**THE ROLE OF ENGINEERING TECHNOLOGY AS A PATHWAY
FOR AFRICAN AMERICANS INTO THE FIELD OF
ENGINEERING**

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LIST OF SYMBOLS AND ABBREVIATIONS

ABET	Accreditation Board for Engineering and Technology
ASEE	American Society of Engineering Education
CIP	Classification of Instructional Program
CRT	Critical Race Theory
ENG	Engineering
ET	Engineering Technology
ETC	Engineering Technology Council
HBCU	Historically Black Colleges and Universities
IPEDS	Integrated Postsecondary Education Data System
NACE	National Association of Colleges and Employers
NACME	National Action Council for Minorities in Engineering
NAE	National Academy of Engineering
NRC	National Research Council
NSF	National Science Foundation
PE Exam	Principles and Practice of Engineering Exam. This also is referred to as the Professional Engineering exam
SPSU	Southern Polytechnic State University
STEM	Science, Technology, Engineering, Math
TID	Technical Institute Division
URM	Underrepresented Minority or Minorities

SUMMARY

Engineering technology serves as a potential, but unequal, pathway for African Americans into engineering workforce. Research and data demonstrate that African Americans are severely underrepresented in the field of engineering. This study explores the role that engineering technology plays in the field of engineering and its impact on African Americans as a potential pathway in the field. The study employs Critical Race Theory as a theoretical framework and uses a mixed methodology (e.g. national data set, faculty and alumni surveys, alumni interviews, institutional curriculum, and state licensing information) for data collection. From these data sources, the study determines that African Americans graduate at a higher percentage rate from 4-year bachelor degree engineering technology programs than from 4-year bachelor degree engineering programs. The study discovers the engineering technology alumni surveyed, including African Americans graduates, chose engineering technology due to program costs, program flexibility associated with their employment, and the hands-on pedagogy of engineering technology. The engineering technology graduates from the study's sample were employed as engineers and not as engineering technologists. Yet barriers exist for graduates of engineering technology program such as achieving licensing as a professional engineering, obtaining federal engineering jobs, and being perceived a subordinate to those with engineering degrees. The present study recommends that engineering technology be elevated to the educational degree status of applied engineering with the appropriate curricular changes. The recommendation brings back the original recommendation of the Grinter Report committee that the United States create an engineering educational system

with two pathways into the field: one scientific/theoretical and one practical/applied. The advantages of such an engineering educational system include the accommodations of multiple pedagogical styles (applied versus theoretical, abstract versus embedded mathematics), an educational system that is more correctly aligned with the industry, a flattening of the engineering hierarchy, and most importantly, an additional legitimized and equal pathway into the field of engineering that better aligns with the life experiences of many African Americans.

CHAPTER 1. INTRODUCTION

A workforce with technological knowledge and expertise is vital to the continued growth of the United States economy. Popper and Wagner (2002:ix) contend that innovation from advances in science and engineering have transformed the U.S. economy and contributed to the well-being of the nation. As technology reduces the value of global location, an increasingly technological workforce is necessary for the United States to maintain a leadership role in the global economy (National Research Center 2007:3; Jobs Council 2011; National Science Board 2017). Other nations understand the value of technological knowledge and expertise and are producing science and engineering graduates at more than twice the rate of the United States (NRC 2007:16,31). A report from the Jobs Council (2011:20) forecasts that the United States needs to increase its investments in higher education in order to begin graduating 10,000 more engineers a year. The report encourages the continued recruitment of individuals into engineering but also recognizes that a primary means of reducing the shortage of engineers is to increase the retention and graduation rates. Clearly, the field of engineering is crucial to the renewal and sustainability of a culture of innovation which acts as a catalyst for economic growth in the U.S. society. The American Society for Engineering Education (ASEE), professional engineering societies and National Science Foundation (NSF) have focused for a long time on broadening or diversifying the participation of women and underrepresented racial and ethnic minorities in engineering.

Because of the importance of the technological workforce in modern society's economic growth and sustainability, technological knowledge and expertise should provide

a pathway to creating upward mobility for all ethnic groups in the U.S. Recent engineering baccalaureate graduates are paid higher salaries (NSF 2014; NACE 2013) than recent graduates from science, mathematics, social and behavioral sciences. Graduates with engineering related degrees are employed at higher rates (NSF 2014). Historically, the field of engineering has provided upward mobility for individuals from lower economic classes (Reynolds 1991; Noble 1977). The historical exception has been for African Americans. In their case, the field of engineering is a system of rigid stratification and social inequality.

1.1 Study Scope

Ashraf and Galor suggest “that a society’s exposure to cultural diffusion, which leads to greater cultural heterogeneity through the introduction of external cultural influences, played a significant role in the promotion of innovation and technological creativity throughout its history” (2013:75). If the field of engineering is crucial to economic growth and innovative competitiveness in the global economy, then the field of engineering must become more diversified because businesses and other organizations which are more diverse significantly outperform those with less diversity (Hunt, Layton, & Prince 2015). Historically, engineering has not embraced diversity which suggests that its impact on economic growth and innovative competitiveness has been hampered. Based on the conclusions of Ager and Buckner, the field of engineering’s potential for economic and innovative impact is not only being hampered by the lack of diversity but its impact on economic development is being negatively affected by the “social destabilizing effect of cultural polarization” (2013:96). Government reports have implored consistently the U.S. “to cultivate the scientific and technical talents of all its citizens, not just those from groups

that have traditionally worked in science, engineering, technology fields (SET). Women, minorities, and persons with disabilities currently constitute more than two-thirds of the U.S. workforce. It is apparent that just when the U.S. economy requires more SET workers, the largest pool of potential workers continues to be isolated from SET careers (Bordonaro 2000:1). Leggon and McNealy (2012) stress that the underrepresentation of minority groups in science and engineering fields effects the economic ability of the United States to function effectively at the global level. The top tier of the engineering field continues to reflect those individuals who have traditionally worked in the SET fields. The second tier represented by engineering technology, however, more closely resembles the diversified educational population and SET workforce that these reports recommend.

The study focuses on the discipline of engineering technology in an attempt to understand its role in the stratified model of engineering as either gateway or gatekeeper for African Americans. This study focuses on African Americans because this ethnic population maintains disproportionately low representation in engineering to the general population than other underrepresented minority groups. The study recognizes the limitations of such a decision and acknowledges the intersectionality of race, socioeconomic status, gender, and sexuality. The study also chooses to focus on the baccalaureate degree level. Though engineering technology programs are offered at the associate degree level, engineering programs are not. In order to maintain an appropriate comparison between the degree programs, the study uses only baccalaureate degrees in its analysis.

If the field of engineering is vital to the economic health of a nation's economy and the occupants of the field of engineering possess higher salaries and occupational prestige,

why are African Americans not utilizing the field of engineering as a pathway to economic success and increased quality of life? The study theorizes that racist mechanisms of control and closure used to maintain a higher status within the stratified U.S. society have created in the field of engineering a culture of inequality through the auspices of the educational credentials. Shapin determined that the scientific community used credentials along with the physical and symbolic siting of experimental work as a means of controlling the experimental discourse (1988:479). Shapin (1994) concluded that scientific pioneers such as Hobbes, Boyle, and others created sacred places where scientific instrumentation and experiments were housed and from which scientific truths were produced. Entry into these sacred places were regulated and constrained so that only a certain group of individuals were allowed to identify themselves as scientists. Natural fact was usurped by the science method of inquiry and closeted away in a social space where technically trained experts produced discoveries at which those outside the boundaries of the black box gaze in awe.

Through institutional discrimination resulting from institutional racism, educational credentials, and licensing, engineering has developed its own regulated membership. It is through “constrained membership,” according to Slaton, “that scientific communities hold onto their unified social identity” (2010:203). Although underrepresented minority groups have been successful in using the pathways of higher education as a means of upward mobility¹, they continue to represent a small share of bachelor’s degree recipients in engineering (NSF 2015). Fechter (1994:138) states that “underrepresentation in part

¹ See Kozol (1991), Kozol (2005), and Bowles & Gintis (2011) for critiques of the U.S. education system as a mechanism for reproducing class structure

reflects barriers that prevent qualified individuals from these groups (*women and minority racial populations, author's italics*) from pursuing” careers in science and engineering. He notes that this underutilization of talent means that these individuals are not being fully exploited and that policy should be implemented to address this underrepresentation. The study posits that African Americans are stymied by these racist mechanisms of control and closure within the field of engineering which prevent them from rising to the top-tier of the engineering social structure.

The study uses a three-tiered, stratified structure as the conceptual framework of the field of engineering. The field of engineering includes all sub-disciplines of engineering such as mechanical, civil, or computer engineering. The three tiers (Figure 1) are represented by engineering, engineering technology, and vocational laborer/technicians. Access granted to each tier is based on certain criteria (degree completion, licensing, accreditation standards, discipline choice, etc.) that are connected to the mechanisms of control and closure. These criteria are determined by various groups such as accrediting bodies, university engineering programs, and state licensing agencies. The idea of this three tiered structure emerged from the formation of the technical institutions in the United States. According to Henninger (1959:27-28),

to produce efficiently an adequate supply of qualified manpower (sic) for the three-part engineering-scientific team, we shall require a three part educational program: 1) The university-collegiate program for engineers and scientists, 2) The technical institute program for the engineering and scientific technicians, and the 3) The vocational-trade programs for the craftsmen and apprenticeship.

The second tier is an understudied area of the field of engineering but its impact on this three-tiered structure of engineering is significant.

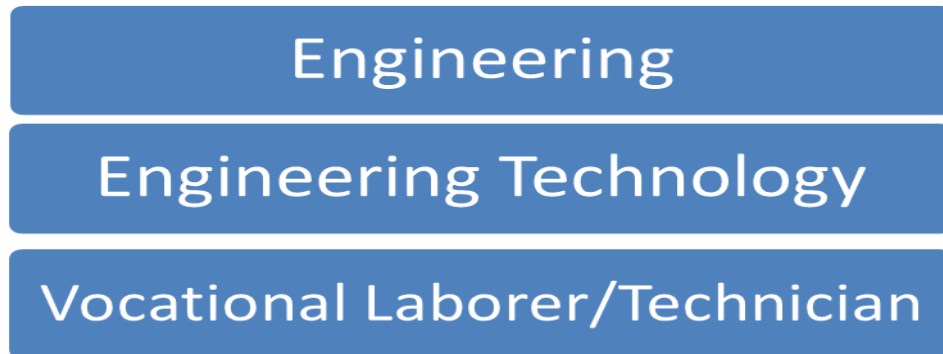


Figure 1 - A visualization of the field of engineering hierarchy.

1.2 Engineers and Social/Professional Status

Engineers have been concerned about their social status in the social structure, be it economic status, occupational prestige, or the professional workforce. Professionalization not only bring increase economic and monetary rewards but it also increases the social reputation of the occupation (Larson 1977:3). Engineering has a long history of seeking to increase professional status among their competitors and their clients. It, therefore, is not surprising that engineering emerges within the stratified structure of the military where the engineer became a permanent fixture during the medieval era, earning the title *ingeniator* (Fox 2006:54; Collins 1979:160-163). In France during the 18th century, military and civil engineers, in attempts to maintain social reputation with architects, established the academies of the *Corps du genie* and *Corps des ponts et chaussees* (Reynolds 1991:8) in response to the *Academie d'Architecture* (Saint 2007:24-

27). This occupational status building “culminated in 1794 with the creation of the *Ecole polytechnic*, the institution that became the foundation for formal theoretical and mathematical engineering education in France” (Reynolds 1991:8). In Britain during the 1800s, however, the rise of engineers took a less formal educational path and emerged through apprenticeships and on-the-job training (Reynolds 1991:12; Saint 2007:42-43). Because of this lack of required formal education, many of these early engineers emerged from lower socio-economic classes (Rae & Volti 1993:33; Saint 2007:43) and “it appears, in fact, that these millwright-engineers were not – as is often suggested – rough, empirical, illiterate workmen, but had usually acquired somehow a fairly good education or training” (Musson & Robinson 1969:429). These beginnings locate the engineering field in a precarious social structure position as the concept of professionalization begins to emerge in the 18th century. As the idea of knowledge as a commodity formulates and the concept of knowledge-based occupations emerges, the field of engineering struggles because of its necessary synthesis of abstract knowledge with concrete skills which are required within the skill set of an engineer.

In attempts to shed this 18th and 19th century European reputation as a dirty, lower class, strictly skills based occupation; it engaged in professionalization activities to increase its occupational and professional prestige. As engineers were incorporated into the 20th century corporation in the United States, they made every effort to distinguish themselves for better management opportunities, “fearing this, engineers sought to differentiate themselves from lower-status occupations, by emphasizing their ‘scientific’ training and their management skills” (Reynolds 1991:177). Reynolds (1991:176) indicates that one reason American engineers sought management opportunities in their

corporations was to improve their status. The struggle for status and professionalism appears regularly in the histories of engineering (Calhoun 1960; Calvert 1967; Layton 1986; Noble 1977). Reynolds writes, “Several studies of the engineering profession in America have suggested that one of the critical elements in the process of professionalization has been the definition of boundaries and relationships between engineering disciplines and their border areas, particularly science and business” (1991:343; See also Layton’s *Revolt of the Engineers* 1986). The boundaries and relationships between engineering and business and science create a subordinate, even proletariat position for engineering. Engineering’s subordinate status to science in social prestige within the academy, government, and corporations is based on the perception that science seeks truth and discovery through pure and basic research (abstract, knowledge) while engineering is the merely the application (technical, skills) of scientific discoveries.

Historically, engineers have sought to increase their occupational prestige and economic social status by increasing academic credentials deemed important by the scientific community and extending their control over the business operations of construction, manufacturing, and technological development through the requirement of professional certification. World War II provided the impetus for this change. Frederick Terman, dean of engineering at Stanford, proclaimed that engineers would not play second fiddle to physicists and pursued changes within the engineering curriculum that increased the scientific and theoretical mathematical requirements for the degree (Seely 1999). In 1955, the final Grinter Report (Grinter 1955) reflected this need to increase the social status of engineers through scientific academic credentials by recommending a singular pathway to an engineering degree that included increased requirements in science and mathematical

courses as well as a move away from applied engineering to theoretical engineering. Engineering's proletariat position (see Noble 1977:63) to business is based on a relationship where business clients (capital) employ engineering (worker) to create a product that creates profit for the business client.

MacDonald (1995:157) writes, "Professions became possible only when knowledge emerged as a sociocultural entity in its own right, independent of established social institutions, and when society came to be based on knowledge in a way quite different from earlier periods; and when the market has reached sufficient salience as a feature of society for the private provision of knowledge-based services to become viable." These knowledge-based services include such occupations as medicine, law, architecture, science, and engineering. Professions are knowledge-based occupations that have effectively gained control over the distribution of their specialized knowledge and directed the socio-evaluation of their knowledge toward a monopolized position. Engineering as an occupation, however, suffers from professionalization envy due to its inability to fully complete the "professionalization project" (Larson 1977). The field of engineering has failed to achieve all the structural tenets of professionalization (Flexner 1915) and, therefore, struggles continually with its ability to claim the status as profession. Although each profession establishes its own infrastructure, these infrastructures seem to include five common tenets: professional organizations, bodies of knowledge, education, professional activities, and certification/licensing (Evetts 2003; Evetts 2011; Trice and Beyer 1993).

The theories of professionalization can be divided into three categories: attribute models, process models, and power models. Attribute or structural models attempt to define the features of a profession. Process models examine the social dynamics and interactions

by with an occupation become a profession. Power models seek to understand the economic and social forces that lead to and shape professionalization (Curnow and McGonigle 2006:286). This study uses the power models of professionalization as a framework of analysis because of these models connections with the study's overall theoretical framework. The models of power are based on theories of action rather and theories of structure which provide a more dynamic analysis of professionalization (MacDonald 1995:1).

Larson's (1977) concept of the professionalization project denotes a series of continuing process that occupations engage in order to develop and maintain their professional status. Larson notes that specialized knowledge is the foundation of the professionalization project but it is the translation of that knowledge into mechanisms of control that accomplish professionalization. Larson concludes that professionalization is the conversion of scarce resources such as special knowledge and skills into an economic commodity with social rewards. This conversion occurs at the juxtaposition of the institutional market and the educational system (Larson 1977:xvii). The professionalization project is a dynamics process between the occupation and a series of social actors. Freidson (1970) argues that the cognitive and normative features of a profession are not static but dynamic and in constant flux as the internal and external actors discuss/argue over boundaries and membership. MacDonald (1995:163) insists that to turn human problems into problems that fall within its jurisdiction, a particular profession must engage in "cultural work" that will ensure that clients, competitors, the state, and the public will acknowledge that the qualities of the problem warrant the granting of jurisdiction. The process changes constantly as different variables (client preferences, technology, new

knowledge, competition) are introduced into the professionalization project of an occupation. The continuous process of maintain professional prestige has both autonomous (controlled by the occupational group) and heteronomous (controlled by other social players) means (Larson 1977:68; Friedson 1970; Friedson 1986:63-73) also makes a similar distinction between occupational and institutional credentialing. The autonomous means include systemic training and testing, normally occurring within the institution of education. The heteronomous means includes registration, certification, and licensing, normally controlled by the state.

It is interesting that within the discussion of power models of professionalization, there is little mention about the power struggles with race and gender. The only recent research on race/gender in professionalization theory centers on the discussion of the “absence” versus “presence” perspectives on inclusion and diversity in professionalization (Ashcraft et al. 2012). The “absence” perspective focuses on the lack of diversity (both gender and racial) in professions as a deficit that needs to be rectified. The line of research coincides well with engineering’s attempts to attract more women and individual of color into engineering. Ashcraft (2012:469) notes that “the task is to advance Others in ‘obviously’ valuable work positions until they reach a critical mass. However, chronic struggles with interventions based in this view suggest that they rarely translate into deep systemic change.” The “presence” perspective connects with the current study’s perspective that a profession maintains its status by intentionally excluding certain groups and thereby controlling the influx into the group.² Ashcraft (2012:471) states the

² See Davis 1996. Though Davis focusses on gender and professionalization, the parallels and connections with race are easily perceived.

“presence” literature “demonstrates that the construction of professions entails not only aligning occupations with particular people, but also contrasting them with lowly Others. Without encoding gender and race hierarchy into its very profile, an occupation tends not to become or remain a profession. It is in this sense that apparently excluded Others are already included in professional identity.” The present study seeks to engage the “absence” perspective by examining the viability of engineering technology as a means for increasing the number of African Americans in the engineering workforce. The present study, however, connects more directly with the “presence” perspective by maintaining that engineering seeks to maintain its professional prestige through mechanism of social control that have limited the influx of African Americans into the field of engineering.

The autonomous and heteronomous means of maintaining professional prestige are mechanism of social control and closure. MacDonald (1995:162) states, “Once again, Max Weber’s conception is of value, because it is (credentialed) knowledge on its own that he sees as the base on which an occupation can establish social closure and enhance its social status.” Engineering’s autonomous means of professionalization include academic curriculum, credentials, and accreditation. Engineering’s heteronomous means of professionalization involves the state licensing of professional engineers and land surveyors and the certification of project documents by licensed professionals. This requirement by the state acts a legal mandate that only registered licensed engineers can certify project documents.³ This legal mandate, however, only pertains to a limited number of engineers, mainly civil engineers, who officially offer their services to the public. The National Society of Professional Engineers estimates that only 20% of practicing engineers

³ See <http://www.nspe.org/resources/licensure/what-pe>

are actually licensed by the state.⁴ The vast majority of engineers in the United States, in disciplines such as electrical and mechanical, are not licensed. This lack of state-mandated licensing emerges from a lack of internal consensus and various forms of dissent on the part of engineers on the need for independence, unionization, and licensing (Meiksins 1991:400,421). When it comes to the autonomous means of systemic training and testing, however, engineering has a strong monopolistic control over accreditation and credentialism of its field in the United States. Accreditation Board for Engineering and Technology (ABET) serves as the official accrediting body for engineering in the United States. ABET accredits over 3400 programs in nearly 700 colleges and university.⁵ These programs reach down into the discipline degree level. The accrediting body sets guidelines for curriculum development, testing, and ethics. Colleges and universities serve as the means of distribution of this knowledge system and seeks such accreditation to validate their programs. Eyal (2013:874) recognizes that the monopolistic form of power exerted to increase professionalization is grounded in the control of the knowledge of the profession (Layton's autonomous means). This control over the distribution of the profession's knowledge controls the supply of its services (2013:875). Therefore the educational system and the control of the engineering curriculum is crucial to the monopolistic control of the profession's knowledge base.

Engineering's professionalization project encounters mixed results. On the one hand, it has almost total monopolistic control over the supply of engineers through the educational process. On the other hand, it has not exerted its full autonomy as a profession

⁴ See <http://ecmweb.com/content/higher-learning>

⁵ <http://www.abet.org/about-abet/>

(Layton 1971; Noble 1977; Reynolds 1991; Meinsins 1991). Engineers in the workplace actually find significant amount of their professional power is exerted through the practice and use of their technical expertise and not through increasing their autonomy. The exercise of expertise is “a “dynamic interdependence” and interplay between monopoly, autonomy, generosity, and coproduction” (Elay 2013:877). This dynamic interaction describes how the engineering field maneuvers between science, academics, other business professionals, clients, and the general public. It is a constant effort to maintain their status in and between these various social groups (Noble 1977:37). Because of engineering inability to gain heteronomous control of their professional status, engineering seeks to exert control in the areas they can control. Collins (1979:160) indicated that it is engineering’s inability to professionalize itself that has given rise to the increasing credentialism expected of its members. The field of engineering’s historical concern with its social location within society has driven it to create mechanisms of control and closure, such as credentialism, accreditation, and licensing (though limited), which help perpetuate the field’s appearance of professionalism and maintain its social position and occupational prestige. MacDonald (1995:35) recognizes that this “overall strategy of a professional group is best understood in terms of social closure. As a basis for understanding the progress (or otherwise) of the professional project, the conflicts and interactions that develop between and within occupations, and a means of grasping the nature of their discriminatory actions, and the way they contribute to the structured disadvantage of gender, race, ethnicity, and so on.” The “presence” perspective affirms this idea that their “discriminatory actions” in limiting access of certain groups (gender and race based) is important to the maintenance of the profession. The intersection of professionalization of

engineering and the concept of social status and closure form the underlining questions of the present study.

1.3 Statement of the Problem and Purpose

The study examines the role of engineering technology within the field of engineering and assesses whether this second tier is a pathway for African Americans into the field of engineering or just another mechanism of control and closure in engineering's stratified structure. Data (Table 1) from the NSF indicates that racial/ethnic minority groups are underrepresented in engineering occupations. Data (Table 2) from ASEE indicates that African Americans are disproportionately represented within the three-tiered model of engineering based on their corresponding population numbers. African Americans are underrepresented in both engineering and engineering technology when compared to the general population but show stronger enrollment in engineering technology. The National Action Council on Minorities in Engineering (NACME) echoed the findings from ASEE when they report that African Americans represent 11.7% of the total U.S. workforce but only comprise 2.5% of engineering managers, 4.5% of engineers, and 7.0% of engineering technicians (NACME 2014). Here we see a clear mapping of the stratified structure of race onto the tiered model of the engineering field with only a small percentage of African Americans reaching the top tier. The Hispanic population appears to be more equally distributed across the engineering and engineering technology tiers but is still underrepresented when compared to the general population. Native Americans,

Table 1 Racial/ethnic distribution of individuals in S&E occupations, S&E degree holders, college graduates, and U.S. residents: 2013 (in percentages).

Race	S&E occupations	S&E degree holders	College degree holders	Total U.S. residential population
Asian	17.4	13.5	8.4	5.2
American Indian/Alaska Native	0.2	0.2	0.3	0.6
Black	4.8	5.8	7.2	11.7
Hispanic	6.1	7.9	7.7	14.6
White	69.9	70.5	74.6	66.2
Native Hawaiian/Other Pacific Islander	0.2	0.3	0.3	0.1
Two or more races	1.5	1.6	1.5	1.6
SOURCE: http://www.nsf.gov/statistics/seind14/index.cfm/etc/tables.htm NSF Science and Engineering Indicators 2016				

Hawaiian/Pacific Islanders and individuals who indicated two ethnic groups are equally represented in enrollment for both engineering and engineering technology when compared

Table 2 Percentage of students enrolled in bachelor degree programs in engineering and engineering technology: Fall 2015

	Engineering**	Engineering Technology**	General Population***
Black	4.6	9.9	13.3
Asian	12.0	5.2	5.6
Hispanic	11.2	9.6	17.6
Other*	3.7	3.9	1.9
White (Non-Hispanic)	55.3	68.2	61.6
Unknown	3.4	3.2	NA
Non Resident Alien	9.8	NA	NA
* Native American, Hawaiian/Pacific Islander, and Two or More Ethnic Categories **Source: The American Society for Engineering Education 2016 *** U.S. Census Bureau 2015 - https://www.census.gov/quickfacts/table/PST045215/00			

to the general population. This initial data support the present study's hypothesis that the stratified model of the engineering field established in the 1940s with the creation of engineering technology programs has had the stratified social structures of race mapped onto it.

The study explores the following questions: *1) has the engineering field created a racially stratified structure that has limited access to African Americans and 2) does the knowledge and technical expertise of engineering technology act as a viable pathway to the field of engineering for African Americans?* The study answers these questions by

employing national data on degree conferred in engineering and engineering technology and using a case study approach of two institutions of higher education in the United States that offer both engineering and engineering technology degrees. Using both national data and an examination at the institutional level provides deep data cuts which in turn expose the complex, multi-stratified structure of the engineering field. Suchman writes “different ‘apparatuses of observation’ enable different, always contingent, subject-object cuts that in turn enable measurement or other forms of objectification, distinction, manipulation, and the like within the phenomenon” (2007:267-268). She suggests that multiple “cuts” provide an expanding view of the configuration of societal action.

1.4 Significance of Study

The study draws from the theoretical studies of critical race theory, social stratification, and the research studies of underrepresented minorities within STEM fields. While these studies provide a strong foundation for the present study, none focus attention on the three-tiered stratified structure of engineering, especially the level of engineering technology. The recent NAE publication (2017:vii) on engineering technology laments that engineering technology is “largely absent from most discussions of the future of the US technical workforce.” The topic of race and underrepresentation in engineering technology is understudied by sociologists of science and technology. Most research on engineering technology has been conducted for the ASEE and focuses on educational pedagogy (Robison 1982; Beaver 1993), curriculum development (McCurdy 1986), and program enhancement (Holloway 1991). Other studies merely use engineering technology students at subjects in unrelated experimental designs (Ellis 1999). A thorough review of the literature reveals that no one has examined the racial, class, or gender stratification and

inequality between engineering technology and engineering. The NAE study recommends that the NSF consider funding of such studies, specifically study's such as this one (2017:7). The discipline of engineering technology, however, educates, perpetuates, and produces a significant portion of the technological knowledge and expertise in the US with 414 institutions (public, private, and for-profit) offering Bachelor's degrees and 1,912 institutions offering 2-year degrees (NAE 2017:13). ABET accredited 121 institutions in the United States to offer 387 accredited bachelor's engineering technology degree program with 30,381 full time enrolled students in 2015 (ASEE 2016).

This study also has significance in that it extends our knowledge about this second tier of the engineering field in light of the increasing need for more engineers and a more diverse engineering population. The Obama administration, through its Job Council report, recommends that action be taken to increase the education output of engineers by 10,000 graduates a year (Jobs Council 2011). The Engineering Technology Council of ABET responded by recommending that the federal government acknowledge engineering technology as a viable path to the field of engineering as does private industry. (ASEE White Paper 2011). The Council seeks to move engineering technology toward becoming an additional pathway to engineering and away from the engineering technician/technologist terminology. The Engineering Technology Council of the ASEE recently adopted a new slogan "Engineering technology is the degree, engineering is the career" that would further merge the top two tiers. If the discipline of engineering technology, as an alternative pathway into the field of engineering, acts a gateway for underrepresented minority groups to enter and prosper in the field of engineering then efforts need to be made to expand these efforts and programs. If, however, the discipline

of engineering technology is a gatekeeper that prohibits these groups from being fully engaged and accepted within the engineering field then efforts must be made to more fully meld together the first and second tiers.

1.5 Theoretical Perspectives

The theoretical underpinnings of the present study are based primarily on critical race theory but also utilizes elements from Weber's theory of stratification expressed through his understanding of status groups as a category of power distribution. Critical race theory provides the macro theoretical framework for analysis. This macro perspective of analysis 1) acknowledges that racism is endemic, 2) racism is dynamic and mutates its societal expressions, 3) expresses skepticism when confronted with objectivity, colorblindness, and meritocracy, 4) recognizes the validity of experiential knowledge of people of color, and 5) seeks the elimination of racial oppression (Delgado & Stefancic 2012; Denson, Avery & Schell 2010; Ledesma & Calderon 2015). Weber's theory of stratification informs the study on a micro theoretical structure of analysis. Weber's idea of status groups as a category of individual and institutional power distribution is further examined by using social closure theory based on Parkin's concepts of exclusionary and usurpation practices and Collins' ideas of educational credentialism as a form of stratification.

1.5.1 Critical Race Theory

Critical Race Theory (CRT) serves as the macro level theoretical framework for analysis and discussion. Since the study focuses on the inequality that exists in the field of engineering as it relates to African Americans, the analysis of the study's findings must

occur within a framework that recognizes racism as a factor which contributes to such inequality. This study aligns with some key perspectives of CRT: 1) acknowledges that racism is endemic, 2) recognizes that racism is dynamic and mutates in its societal expressions, 3) expresses skepticism when confronted with objectivity, colorblindness, and meritocracy, 4) acknowledges the validity of experiential knowledge of people of color, and 5) seeks the elimination of racial oppression (Delgado & Stefancic 2012; Denson, Avery & Schell 2010; Ledesma & Calderon 2015). One of the primary tenets of CRT is that racism is endemic in society and recognizes “the centrality of race and racism in shaping the everyday life experiences of all people, but especially for people of color” (Ledesma and Calderon 2015:214). As part of the literature review, the study examines the role of institutional racism that feeds the field of engineering. This institutional racism is embedded in the societal structure and therefore impacts the educational system that inadequately prepares Black students for science and engineering pursuits, infects the historical structures of engineering accrediting bodies, and results in the creation of parallel but unequal pathways into the field of engineering through intentional efforts like the Historical Black Colleges and Universities (HBCUs) and unintentional efforts like engineering technology degree programs.

Racism is not a static, fixed phenomena that exerts itself in a unilateral direction or in monolithic behavior. Racism is a dynamic phenomenon that “mutates and multiplies, creating a range of racisms. We must be able to bring up issues of race and racism without the terms always leading to fear, alienation, and off-point debate” (Bell 2008:624). Because of this dynamic process of mutation and multiplication, this study holds that racism becomes embedded in the structural layers of society and expresses itself in multiple

manifestations. This study highlights these racist expressions manifested in institutional discrimination or institutional racism such as the inadequate preparation of Black students for science and engineering pursuits, selection process of students into institutions and engineering programs, the curriculum expectations of engineering programs, the retention, attrition, and graduation of student populations, and the credentialing and employment of engineers. These racist expressions are constructed by the dominant group as mechanisms of control and closure to regulate and distribute the flow of individuals into the fields of engineering. CRT seeks to “expose how majoritarian structures have historically shaped and framed educational access and opportunity for historically underrepresented populations” (Ledesma and Calderon 2105:214).

Because racism is embedded in the structural layers of society, CRT expresses skepticism when confronted with objectivity, colorblindness, and meritocracy. This institutional racism produces inequality through the allocation of privilege and status, which benefit the dominant groups. The importance of mathematics and theoretical pedagogy appear as meritocracy but become mechanisms of control and closure. CRT writers who hold to this perspective are referred to as realists, “as opposed to the idealists where race is a social construction so issues of words, language, social teachings are addressed” (Delgado and Stefancic 2012:21). This study also emphasizes the importance of experiences in understanding the multifaceted dimensions of race within the field of engineering. Therefore, the data on admission criteria, enrollment, degrees conferred, curriculum requirements, and survey results in this study is augmented with the words and experiences of faculty and alumni who have experienced the structures that produce the data. Voice and narrative give power to the numerical data and help us “come to a deeper

understanding of how Americans see race” (Delgado and Stefancic 2012:44-49). Delgado and Stefancic recognize the black-white racial binary as a bias of CRT. Discussions of race in the United States within the writers of CRT and population in general are typically viewed as the binary between whites and African Americans or black (2015:75). Therefore, all other minority ethnic groups are measured or compared to this particular binary and the normative standards it produces. This author recognizes this bias as evident in the study’s assumptions and analysis.

The study uses the terms race, ethnicity, and racism. These terms need to be defined for this study because each is infused with numerous interpretations. Older conceptions of race and ethnicity described race as biological and ethnicity as cultural. Those older and static conceptions have been replaced with more dynamic and fluid ideas about race and ethnicity. Race is not biologically determined but is a social construction and thereby socially imposed and hierarchically determined (Conley 2003; Omi and Winant 1994; Waters 1999; Winant 2000; Clair & Denis 2015). Since the terms of race and ethnicity are many time confused, interchanged, and diluted and because this study will utilize the concept of race as opposed to ethnicity for group categorization, let me define how race is different than ethnicity. Conley (2003) suggests an individual can have multiple ethnic affiliations but belong to only one racial group. Freund (2003) argues that racial categories have more direct impact on individuals than ethnicity because of the ascribed and determined nature of racial classification. These ascribed natures emerge from the physical characteristics such as skin color and facial features and the determined categorization of individuals into particular racial groups based on these ascribed characteristics (Omi and Winant 1994; Waters 1999; Cornell and Hartman 2007). The study chooses to use a

nationally recognized database as a primary source of data analysis. This particular database utilized a specific racial categorization (Black, Hispanic/Latino, Asian, White, etc). Therefore race, as opposed to ethnicity, is used as the primary form of categorization in the study. The term African American is used predominantly in the study to describe those who identify themselves as “Black” through the national database and in the administered survey. The study does follow the NSF’s uses of racial categories.⁶ The study admits its limitations on the use of race because it treats this term as a set of categories due to the data sources being used which utilize predetermined categories of groups. The use of these predefined categories and the limited scope of the study do not provide the opportunity for a full analysis of race.⁷

Taking into account the tenets of CRT, the study specifically defines racism as a process of racialization whereby individuals are determinedly categorized based on certain ascribed characteristics into the categories of “races” and “involves the hierarchical and socially consequential valuation” of these racial categories (Clair & Denis 2015:857). Racism manifests itself in various forms and, as theorized by CRT, is mutable and dynamic. This study will consider racism in its forms of institutional discrimination which manifest itself through the unequal treatment of races and racial inequality which manifest itself through the distribution of unequal outcomes (Clair & Denis 2015).

⁶ See <https://www.nsf.gov/statistics/2017/nsf17310/technical-notes.cfm>

⁷ The study uses “race” when utilizing the predefined categories of the IPEDS data. The study agrees with Morris (2007) that “marking race in one particular way might not be ‘wrong,’ it is certainly one-dimensional and typically noncritical.” The study clearly admits that its use of race as a category of analysis is one-dimensional and noncritical. A fuller analysis of race would include the more contemporary and comprehensive theories of race such as Omi and Winant’s racial formation theory (1994), Bonilla-Silva’s racialized social systems theory (1997), and Feagin’s theory of systematic racism (2006). In the theory of racial formation. It also would include arguments that reduce race to a component of ethnicity (Wimmer 2013) or even question the essentiality of race (Loveman 1999).

1.5.2 Weber's Theory of Stratification

Weber (1978) discusses the distribution of power within the political community within the categories of class, status, and party. Weber argues that the boundaries between social groups are not limited to one's class situation and relationship to the means of production as argued by Marx. Weber argues that these divisions and boundaries are more intricate and complex. Weber outlines specific characteristics of these group categorizations such as 1) wealth, property, and life chances for class, 2) honor, style, and occupation for status, and 3) politics and goal orientation for party (1978). The proposed study uses Weber's concept of status group to describe the power distributive category in which the field of engineering resides. Status groups are formed through various sources including differences in life chances which are based economic position (occupation, one's power position), or on cultural circumstances (religious affiliation, geographic origins, race/ethnicity/gender, or education). Depending on the occupation and that occupation's status within the culture, an individual or group obtains a certain social location based on that particular status group within the stratified status structure. Engineers are considered part of a highly esteemed occupation group and are accorded "social honor by virtue of the special style of life which may be determined by it" (1978:124). Such high social esteem, occupational prestige, specialized forms of knowledge and expertise, and educational credentials are forms of power which engineers use to maintain their group's boundaries and the three-tiered structure of engineering.

Social closure refers to the monopolization of power to enhance or protect a group's social position, status, or rewards through two processes of exclusion and usurpation (Parkin 1979). Exclusionary closure is a process where one group "secure for itself a

privileged position at the expense of some other group through the process of subordination” (Parkin 1979:45). Various forms of closure codes (see Murphy 1984) are used to monopolize certain material forms of power or resources. Murphy writes, “The limitation of access to all resources-land, arms, means of production, or knowledge-on whatever basis to a restricted circle of eligibles is conceived as founded on one and the same generic kind of process which constitutes monopolization and closure” (1984:548). Usurpation, on the other hand, is an upward process by which individuals or groups seek to break down the barriers of exclusionary codes in order to obtain more prestige, status, or reward. Parkin understands that exclusion and usurpation can work as dual processes of social closure and that certain groups can engage in the process of usurpation while at the same time employ exclusionary processes upon other groups. Within the field of engineering and the study’s conceptual model of a three-tiered structure of engineering, the idea of social closure would include the exclusionary codes necessary to maintain the three-tiered structure and manage the flow of individuals into between the three levels. It would also include usurpation efforts by those in bottom two levels or external entities to eliminate or modify the exclusionary codes set in place by the top tier.

Parkin (1979) argues that the modern capitalist society employs two exclusionary devices, property and credentials, and that these devices are legally supported by the state. Credentialism is a “form of closure designed to control and monitor entry to key positions in the division on labor” (Parkin 1979:48). This device of exclusionary closure related to the occupational division of labor is employed within the three-tiered field of engineering model. This exclusionary device or code operates primarily through control of the influx

of individuals into a career field thus providing a leverage for power in the labor market (Giddens 1980).

This particular closure process is central to the study's concept of a three-tiered structure of engineering as certain levels of education, degree credentials, and professional licensing are essential for membership in each tier. Murphy asserts, "Education, like ethnicity and social class, is conceived as a status culture that often has little proven relationship to on-the job performance and to that extent it is a cultural rather than a job performance basis of exclusion from work position" (1984:550). Weber argues that the desire for regularized curriculum and specialized licensing is "not a suddenly awakened 'thirst for education' but the desire for restricting the supply of these positions and their monopolization by the owners of educational certificates. Today the 'examination' is the universal means of this monopolization" (1978:1000). Education as an exclusionary code is important because the level and type of educational credentials possessed by an individual reflects membership in a certain status group and the members of the particular status group control membership within the group through the process of employment. Collins states that "education will be most important where the fit is greatest between the culture of the status groups emerging from schools, and the status group doing the hiring" (Collins 1971:1012).

Collins' stratification concepts of creeping credentialism and the politics of professions are also important to the proposed project's analysis of the field of engineering. As status groups continue to seek monopolization of power to maintain their prestige, status, and rewards, they continually refine and alter their exclusionary codes in ensure control of membership. Many times this means raising educational standards for group

membership because the current levels of education credentials have become saturated. When a certain level of education becomes recognized as a criteria of elite status, and more moderate level of education becomes a criteria for middle-level status, then increases in the supply of educated persons at each level results in higher levels of education being created and designated as the new superior standard, and previously superior levels become relegated to the moderate levels (Collins 1971).

Another means of exclusionary code refinement is the politics of professions. Occupational status groups create boundaries to better define themselves to their clients and against other potentially usurping status groups through the concept of professionalization. A profession is defines as a “self-regulating community” which possesses “exclusive power, usually backed by the state, to train members and admit them to practice” (Collins 1979:132). Professional standards are set and maintained by the current insiders of the particular occupational status group. Professions normally possess knowledge, expertise, or skills which not commonly held or easily obtained by outsiders. Collins (1979:132) identified medicine as a primary example of a profession but notes how engineering has struggled in its efforts to classify itself as a true profession. Collins’ perspective coincides with the proposed project’s historical analysis of the field of engineering and the constant struggle of engineers to obtain, refine, and maintain a certain occupational status and prestige. He asserts that status interests and internal conflicts among engineers have been the primary reasons which kept engineering from challenging the non-technical educational system and from gaining higher social status in the larger system of stratification through its status group membership and financial and political resources (1979:160). Collins notes that no sharp division exists between engineers,

technicians, and mechanics yet this “field” of engineering is found in every industrial society (1979:159). Yet in regard to the proposed project’s three-tiered model of engineering, Collins (1979) notes that technicians are distinguished from engineers, not by their technical abilities or expertise, but by their educational credentials.

The intersection of these theories is the idea that racism manifests itself in mutable forms which act as mechanisms of social control and limits access to African Americans into the field of engineering. This interactional idea theorizes that engineering is motivated by the need for prestige and status, personified in their desire to be considered a profession, and, in order to obtain that prestige and status, has employed racist means of social closure that has resulted in an underrepresentation of African Americans in engineering. The intersection of these theoretical perspectives informs the analysis of the data in answering the study’s research questions. In order to answer the question “has the engineering field created a racially stratified structure that has limited access to African Americans” the study must be aware of the mutable forms of racism that have existed historically and continue to permeate the field of engineering and how these mutable forms have acted as means of social closure. In order to answer the question “is engineering technology a viable pathway to the field of engineering for African Americans” the study must examine the reasons why individuals chose engineering technology and the obstacles they face in their engineering careers in terms of mutable forms of racism as means of social closure.

1.6 Organization of the Dissertation

This dissertation is organized into six chapters. Chapter 2 provides an overview of the relevant literature. This literature includes an overview of the historical development

of engineering technology and review and analysis of studies which focus on race within the STEM fields and more specifically the fields of engineering. Chapter 3 provides an in-depth look at the methods used in this study, including the collection of numerical and categorical data on degree conferred and curriculum requirements, surveys of faculty and alumni from engineering technology programs, interviews of engineering technology alumni, and the framework used to analyze the data. Chapter 4 presents the data on degrees conferred, curriculum requirements at the participating institutions' programs in engineering technology and engineering, and state criteria for the Principles and Practices of Engineering (PE) Exam. The national IPEDS data on degrees conferred is compared at the national, state, and institutional level. Chapter 5 provides the results of the survey of engineering technology faculty and alumni at the participating institutions as well as statistical analysis of the survey. It reviews the thematic data collected from the interviews of alumni from the institution's engineering technology programs. Chapter 6 analyzes, discusses, and draws conclusions from the data presented. It also includes potential implications for public policy as well as study limitations, contributions to the field, and future direction for research on engineering technology.

CHAPTER 2. LITERATURE REVIEW

This study is supported by a foundational framework which gives support and provides insight to the role of engineering technology in the racially stratified structure of engineering. This chapter provides an overview of this foundational framework which includes historical, analytical, and theoretical literature. The chapter begins with a review of the history of engineering technology in the United States and the role that engineering technology plays in the stratified structure of engineering. Using the theoretical framework of social closure and boundary work, engineering technology's inferior status to engineering is revealed and the impact this status has on its development is discussed. The chapter also exposes the lack of research in engineering technology. I then examine the analytical literature on African Americans and STEM education, especially those studies that deal directly with engineering. From this analysis, key components emerge that guide the dissertation's research themes, such as the importance of mathematics, hands-on/applied educational pedagogy, and financial and life chance access to academic programs.

2.1 History of Engineering Technology

The emergence and expansion of engineering technology degree programs is a convergence of several distinct streams associated with the United States' need and desire for technological development. These distinct streams include 1) the United States' desire to remain the preeminent leader in technology and innovation, 2) a series of engineering education reports, 3) the development of technical institutes, 4) the expansion of the junior and community college programs in technical education, and 5) the consistent move of

U.S. engineering programs toward more scientific knowledge and theoretical foundations. The two world wars emphasized the need for scientific knowledge creation, technological innovation and development, and increased engineering expertise (Hammond 1944) in order to maintain global leadership and military dominance. The report states, “It is a matter of vital concern to the nation in relation both to security and economic welfare that the highest levels of scientific and engineering excellence be maintained at all times” (1944:592). The convergence of the first three streams provided the impetus for the creation of the technical institutes and the creation of the three-tiered structure of engineering. This three tiered system is hierarchical in nature and consists of engineers, engineering technologists, and engineering technicians/technical labor. Later, the expansion of the junior and community colleges into technical education and the increased emphasis of scientific and theoretical knowledge in engineering programs drives engineering technology programs to expand into four year baccalaureate degrees. The creation of three-tiered structure and the move into four year baccalaureate degrees creates a branding and boundary dilemma for engineering technology. Throughout its existence, engineering technology constantly seeks to delineate itself from both the top and bottom tier.

2.1.1 The First Convergence

In the 1923-1929 report on engineering education, W.E. Wickenden and H.P. Hammond (1930) include a supplemental report on technical institutes. The report recommends that engineering education be expanded and a bifurcation must occur between the professional engineer and the practical engineering technician. Wickenden and Hammond recommended the technical institutes as the locations for this practical form on

engineering education. Hammond (1940, 1944) repeats the same recommendation in his 1940 report on engineering education and his 1944 report after World War II.

The 1940 report states that technological education must be offered on a broader, not narrower basis, and that scientific and engineering knowledge must be diffused “among the industrial classes rather than to canalize it in strictly professional channels. In view of their broad function and their complex relationships, we consider it neither feasible nor socially desirable for the present group of engineering colleges to limit their aim to the preparation of young men for professional registration and practice” (Hammond 1940:560). The report recommends that until other institutions can be developed to house and administer this form of technological education then the engineering colleges must suffice.

In the 1944 Hammond Report, this practical form on technological training morphs into an “industrial group” track of technical education that “gives major attention to matters relating to production and operations” (1994:592). The report noted the lack of a systemic technological education at the “intermediate and sub-professional” level (Hammond 1944:605). A reason that the report gives for the underdevelopment of this form of technological education is the lack of recognition afforded to these degree programs and their graduates from “industry, the engineering profession, and the public at large” (1994:605,607). Again, the issues of social status and occupational prestige play important roles in the distribution of technological knowledge and expertise. The report states, “Lack of such recognition – or accreditation – caused the provisions of the engineering defense training appropriations to limit the offering of courses to degree conferring colleges at the

very time when institutions offering sound programs of technical institute type ought to have been rendering service of great value to the war effort” (1944:606).

These reports, along with the motivation provided by the World War II, lead to the establishment of many technical institutes. By 1945, the first engineering technology programs were accredited by the Engineers’ Council for Professional Development (ECPD 1954; Smith 1956), predecessor to ABET, and the Commission had established a separate accreditation board for engineering technology programs (Smith 1956:31). From 1946 to 1962, the Committee of 21 provided oversight for the emerging engineering technology programs. It served as the precursor to the current ASEE Engineering Technology Council. Just as engineering technology evolved so did the nomenclature of this oversight group. It was renamed the Technical Institute of Administrative Council in 1965, the Technical College Council in 1971, the Engineering Technology College Council in 1981, and, finally, the Engineering Technology Council (ETC) in 1987 (O’Hair 1995:9-10). This constant name change is also reflected in the numerous name changes of institutions that offered engineering technology.

The technical institutes were mentioned frequently in both the Wickenden and the Hammond Reports. A technical institute is defines as, “A postsecondary institution whose curriculums 1) are one to three years duration, 2) are technological in character, and 3) emphasize understanding and application of scientific principles more than manual skills” (Smith 1956:3). This emphasis on scientific principles versus manual skills separated the technical institutes from junior colleges or vocational training institutions. As will be seen, confusion with these forms of education will cause the technical institutes to make serious changes in the 1960s and 70s. Two precursors to the technical institute were industrial

technology programs and the mechanics institute. The industrial technology programs provided postsecondary education and training, but most, however, focused on business management, production operations, and labor relations (Barnhart 1963) and few dealt directly with technological knowledge and expertise. Running parallel to these industrial technology program were the mechanic institutes (Defore 1966:68-69). These institutes were geared toward “the maturing technology of the time, laying emphasis upon application with intensive instruction during short periods of less than four years” (Graney 1965:9). Prominent engineering schools such as Rochester Institute of Technology, Milwaukee School of Engineering, and the Wentworth Institute of Technology began as mechanic institutes (Smith 1956:11,20-25). A key component of technical institutes is that they provide an educational and training experience for the “an area between the skilled crafts and the highly scientific professions” (Smith 1956:4). Ultimately, such stratified thinking led to a three-tiered structure of the engineering field. “The basic objective,” writes Herringer, “of the technical institute idea in higher education is the development of qualified engineering technicians proficient in a selected field of technology” (1959:16). It was not intended as a feeder programs into university/college engineering programs but was to stand on its own as a primary degree granting institution. The clear expectations of this degree programs and its graduates was to be part of the engineering-scientific team (Herringer 1959:20-21). Herringer clearly places the engineering technician in this structure of engineering:

The first fact is that some adequate and integrated provision must be made to continue the supply the technically competent manpower (sic) required for this engineering application and operation, and required also to augment and to supplement the professional engineer and the scientists in research, design, development, and supervision. This manpower (sic) is part of the over-all engineering manpower (sic) spectrum. In general effect, it is

taking the place of the engineer as we have known him, as the engineer of today and of tomorrow increasingly takes his place and becomes more and more devoted to the scientific problems and opportunities of the expanding technological universe. This manpower (sic) area is the professional area of the “engineering technician” (1959:20).

This spectrum of engineering which includes the engineer, the engineering technologist/technician, and the laborer/technician has a hierarchical nature, associated with educational outcomes and achievement, so that movement up the three-tiered spectrum is constrained and regulated.

War provides impetus for technological knowledge and expertise. World War II provided the stimulus needed for the convergence of these engineering reports and the programs offered at the technical institutes. Government and industry officials realized that the United States needed a cadre of technically trained support professionals to work with engineers in developing the infrastructure and technology of the post-war world. The 1944 Hammond Report states “War conditions have furnished a striking demonstration of the need for technological training of intensive nature, at a level between that of the vocational and secondary schools and that of the engineering colleges” (605). In response, the federal government “created a series of programs to train technical assistants, and this release engineers, scientists, and industrial managers for higher level technical and supervisory activities” (Grayson 1977:62). In a response to the Associated Industries of Georgia’s request for such training programs, Professor L.V. Johnson of the Georgia Institute of Technology, using an apt metaphor for the times, clearly identified the social space of this new engineering technician, “Georgia Tech is providing the officers of industry and industry can train the privates of industry, our great need is for the sergeants

of industry” (Bennett 1997:7). Government and industry officials fulfilled the Hammond Report’s recommendation to create an occupational position between the craftsman/laborer and the engineer and from this initiative emerged the concept of the engineering technician or technologist, a term recommended by the ASEE (1962:11). Between 1945 and 1955, the number of technical institutes increased from 44 to 69. (Smith 1956:46). These technical institutes and engineering technology programs followed a series of boom and bust enrollment cycles (Harris & Grede 1977). From 1946 to 1954, the programs surged in enrollment with the influx of WWII veterans and the GI Bill. From 1954 to 1957, enrollment stabilized or decreased due to the movement toward humanities and arts by entering college students (Carr 1979:15). In the 1970s, a number of engineering technology programs moved from two-year associate degrees to four-year bachelor degrees. The 1972 “Engineering Technology Education Study” was a key ASEE report that led to the development of different accrediting criteria for the associate and baccalaureate degree programs (O’Hair 1995:25).

2.1.2 The Second Convergence

The second convergence that expanded engineering technology programs began in the 1960s with the increased emphasis on a more scientific and theoretical engineering programs and the offering of associate’s degrees in engineering technology by junior and community colleges. In the wake of Sputnik, a shift occurred in engineering programs toward the acquiring of more theoretical knowledge by incorporating additional science and mathematics courses “at the expense of design and application based laboratory courses” (Holloway 1991:94). As a debate over the engineering curriculum grew, S.C. Hollister, president of the ASEE, commissioned a new review of engineering education

which would become to be known as the Grinter Report (Floyd 2012:1345). A primary recommendation of the Grinter Report was an increase in mathematics, physics, and engineering sciences (Grinter 1955:25). Engineering technology is affected by this recommendation as well as another recommendation that did not make it into the final report. The recommendation that did not make into the final report was that engineering should be bifurcated into two forms (Seely 1999:291): one form would focus more on the scientific and theoretical aspects of engineering and educate engineers working in research and design for the government while the other form would focus on a more general/practical/technical aspects of engineering and educate engineers for industry. The committee reviewing the report, led by Hollister, did not approve of this recommendation and removed it from the final report.

Thus in the wake of Sputnik and the Grinter Report, a shift occurred in U.S. engineering programs toward the acquiring of more theoretical knowledge by incorporating additional science and mathematics courses “at the expense of design and application based laboratory courses” (Holloway 1991:94). As engineering programs began to move toward a more scientific and theoretical orientation, the applied nature of engineering became de-emphasized. Engineering programs began to add more physics, chemistry, and higher level mathematics courses to their engineering curriculum. Laboratory and shop courses, trademarks of engineering technology programs, were replaced by theoretical design and science courses. Dr. Winston Purvine, founder of the Oregon Institute of Technology, relays a story about the dean of the College of Engineering at Michigan State commenting in a speech to the ASEE that his institution “has literally plowed under acres” of laboratory space as they moved to more mathematics and scientific

engineering (O’Hair 1995:263). This shift by the engineering programs toward scientific/theoretical engineering (and its decision not to bifurcate its programs) created room for expansion of the engineering technology programs and a resurgence on their enrollment growth.

Engineering technology responded by filling this vacuum. The hands-on nature of engineering technology filled this “applied” vacuum and moved engineering technology toward becoming what engineering used to be. The engineering technology programs responded by creating four year degrees and a new occupational position was created; that of the engineering technologist. Ungrodt writes,

Some of the changes in engineering technology education have resulted from the changes in engineering education. The development of science oriented engineering curricula and the trend toward advanced level programs in engineering, as well as the rapid growth and development of associate degree programs in engineering technology, have stimulated the development of baccalaureate programs in engineering technology (1975:787).

Dean Michael Mazzola at the Franklin Institute in Boston states this response quite clearly, “the technical institute group, engineering technology, jumped into the gap. And this is why the four-year program was started, because engineering colleges were not doing engineering; they were putting too much emphasis on science” (O’Hair 1995:216). The development of four-year baccalaureate engineering technology programs stimulated enrollment growth in engineering technology but it further obscured engineering technology’s identity. Now that engineering technology was operating on the same “four-year” playing field as engineering what were the distinguishing feature of engineering technology that set it apart from engineering.

The other stream that motivated engineering technology programs to move from two-year degrees to four-year degrees was the increasing number of junior and community colleges that were offering associate's degrees in engineering technology. At the 1958 mid-year meeting of the Technical Institute Division, Curriculum Development chair H. H. Kerr voiced concern over the "inroads" that the vocation system were making into technical education. Chairman Kerr noted that the vocation system was much larger and politically stronger than the technical institutes and could pose a significant threat to engineering technology. During these proceedings the term "technologist" was first used to describe an engineering technology graduate (O'Hair 1995:118). Much of the concern was that the technical institute programs had been confused with the vocational technical school programs because of their two-year duration. The addition of engineering technology programs at the vocational schools and junior colleges would only add to the confusion, therefore, the "expansion of the long standing engineering technology programs from two to four years is at least one way of maintaining the differential in level and standard which has existed between the technology programs and the vocational programs" (Foecke 1964:12). The need to maintain respectability and social status, both in the academic and industry arenas, leads the traditional programs of engineering technology to elevate their programs to the baccalaureate level.

This second convergence leads Morrissey to declare, "the technical institute today is moving toward the position occupied a short time ago by the engineering college" (1962:97). Because of these convergences, ABET accredited bachelor's degree programs in engineering technology soared from 2 in 1967 to 155 a decade later (ECPD 1978). Enrollment growth in these programs followed and engineering technology established

itself as a baccalaureate degree program. By seeking to fill the vacuum left by engineering's decision to become more theoretical and to distinguish itself from the junior/community college programs, proponents and educators create a new identity for engineering technology. This new identity, however, proves to be a difficult to delineate from engineering. When engineering technology operated at the two-year program level, the stratified structure of engineering was clear. But when engineering technology begins to operate at the four-year program level that stratified structure becomes blurred. Since engineering programs remained clearly on top of the field of engineering hierarchy, engineering saw no need to expend effort in delineating itself from engineering technology. The strategy and effort to define and delineate this new engineering technology identity would be left solely to the proponents of engineering technology.

2.1.3 Engineering Technology's Status and Boundary Work

Historically, engineering technology struggled with its identity, especially in relation to engineering. TID chair Charles Jones reported to the 1953 annual meeting that a lack of information and misinformation existed concerning the technical institutes. He stated that “parents, prospective students, educators, the engineering profession, and industry” do not understand the purpose of technical institutes, their place within higher education, and the value of their graduates (O’Hair 1995:109). In the 1955 annual meeting, Walter Hartung, chair of the Cooperation with Government Agencies committee, reported that the committee encountered amiable reception to technical institute education by the governmental agencies but there existed a simple misunderstanding. These governmental agencies had no idea any information existed on technical institutes and their programs (O’Hair 1995:111). In the 1975 annual meeting, concern was raised that the Civil Service

Commission excluded the engineering technology bachelor degree from their listing of engineering positions. The 1978 annual meeting participants discuss the problem of not having a separate occupation category in the 1980 census for engineering technology graduates. The limited use of the term “technologists” by industry was indicated as a continuing problem (O’Hair 1995:163).

In efforts to mediate this continuing inferior status, the Technical College Council recommended in 1980 that the ASEE change its policy on the selection of ASEE president so that it was rotate between the engineering division and the engineering technology division. That proposal was rejected by the ASEE board (O’Hair 1995:167). In 1982, however, even without the approval of their proposal, Richard Ungrodt, a prominent engineering technology educator, ran unopposed for the presidency of the ASEE. Yet this recognition by academic engineering did not come easy and engineering technology academics bemoan the resistance that they receive from engineering deans. Kohler notes that academic “disciplines are political institutions that demarcate areas of academic territory, allocate the privileges and responsibilities of expertise, and structure claims on resources” (1982:1). The resistance demonstrated by engineering deans manifested itself in vocal and political opposition to the engineering technology’s move from two-year to four-year degree programs and ASEE departmental divisions. The engineering deans voiced their concerns that baccalaureate engineering technology degrees were an encroachment on the profession degree programs of engineering (O’Hair 1995:214,265). The engineering deans also were opposed to allowing engineering technology professionals into their departmental divisions at ASEE. Therefore, engineering

technology practitioners had to develop their own engineering technology division within ASEE (O'Hair 1995:281).

The opposition raised by the engineering deans was an attempt at imposing social closure and thereby protecting their monopolization of power. The four-year baccalaureate degree had been the mechanism of control that maintained engineering's power over the other tiers of engineering. Now, engineering technology had breached that mechanism of control. Opposition to rotating leadership and inclusion in the ASEE division are means of establishing further mechanisms of control. Engineering technology's inability to breach these new controls (and others such as PE licensing) demonstrates its subordinate role to engineering.

Offering four-year baccalaureate degrees provided engineering technology with increased academic and economic status but it only exacerbated their identity crisis. In 1981, the findings of the *Review of Engineering and Engineering Technology Studies* were distributed to the Council's business meeting. The first conclusion highlighted the continuing struggle with the identity of engineering technology in the structure of engineering. It stated, "The results of this survey showed the relationship of engineers, engineering technologists, and engineering technicians are and will be in a state of flux and evolution" (O'Hair 1995:168). This statement has proved to be prophetic. Engineering technology as both an education degree programs and a career pathway remains in a state of flux within the field of engineering. The blurring of boundaries between engineering and engineering technology and the inability to effectively delineate between them places engineering technology in a precarious position where it must constantly be defining and managing these boundaries.

Gieryn (1999) coined the concept “boundary work” to refer to strategic actions that scientists took to demarcate themselves and their work from “non-science” groups and activities. Boundary work is a series of processes and actions, by which groups create, manipulate, transform, dissolve, and reform their symbolic and social boundaries. Boundary work has been used to demonstrate the demarcation between science and non-science (Gieryn 1999), knowledge boundaries as source and barrier to innovation across organizational groups (Carlile 2002), and the accumulation of social capital within a given field (Burri 2008).

Boundary work between social groups is a well-established theme in sociology. Durkheim’s concept of the division of labor (1984) as an ordering effect on society separates groups into their social location boundaries and his *Elementary Form of Religious Life* (1965) separated the sacred and profane elements of society into bounded spheres. Weber’s (1978) classification of status based on wealth, prestige, and power demonstrates the effects of boundary making between class, religion, and race. Bourdieu’s (1984) concepts of habitus and field are used to create and normalize boundaries and distinctions between social participants and groups.

Groups create, maintain, and transform their symbolic and social boundaries through the manipulation and control of knowledge, expertise, and power. These elements help distinguish the group from others. Ash (2004) demonstrates how expert mediators were able to use their newly acquired theoretical knowledge of expertise to elevate themselves above the craftsmen of skill and place themselves in a position of power between these craftsmen and their former wealthy patrons. By using knowledge, expertise, and power, the expert mediators created a new social group within the English economic

system through the process of boundary work. Knowledge is an accumulated investment in particular ideas and practices by a group for the purposes of constructing a social boundary. Expertise or practice is a “shared routine of behavior” (Whittington 2006:619) and is knowledge that is “localized, embedded, and invested” (Carlile 2002:442) by the group.⁸ Power in boundary work is a form of ideology where “groups struggle over and come to agree upon definitions of reality” where by groups determine their power through “unequal access to and unequal distribution of resources (material and nonmaterial) and social opportunities” (Lamont and Molnar 2002:168). Boundary work is consistent with Giddens’ structuration concept (1984) where action embedded in the social structures simultaneously produces, reproduces, and transforms those structures.

Knowledge. Gieryn (1983) states that much boundary work deals with the issue of knowledge and knowledge based information. This idea connects with Fleck (1979) understanding of the “thought worlds” of scientists and Brown and Duquid’s (1991) concept of “knowledge boundaries.” Gieryn’s analysis of scientists and their actions to establish a “rhetorical boundary between science and some less authoritative, residual non-science” (1999:4-5) focuses on the scientists use of knowledge to demonstrate their superior practices, cement their authoritative power, and construct “a social boundary that distinguishes some intellectual activities as “non-science” (1983:782). Through boundary work, certain knowledge is ruled out (Friman 2010:6).

⁸ Zietsma and Lawrence (2010) argue that boundary work and practice work are interrelated forms on institutional work that interact in a “recursive relationship” (191). This paper acknowledges this concept as enlightening and beneficial to the current study but chooses to fold practice work into the more encompassing concept of boundary work.

The following attempt at delineating between the two degree programs serves as good example of the state of continued flux that engineering technology must engage. ABET, the national accrediting body for engineering and engineering technology programs, defines engineering and engineering technology in the following manner:

Engineering and engineering technology are separate but closely related professional areas that differ in:

Curricular Focus – Engineering programs often focus on theory and conceptual design, while engineering technology programs usually focus on application and implementation. Engineering programs typically require additional, higher-level mathematics, including multiple semesters of calculus and calculus-based theoretical science courses, while engineering technology programs typically focus on algebra, trigonometry, applied calculus, and other courses that are more practical than theoretical in nature.

Career Paths – Graduates from engineering programs are called engineers and often pursue entry-level work involving conceptual design or research and development. Many continue on to graduate-level work in engineering. Graduates of four-year engineering technology programs are called technologists, while graduates of two-year engineering technology programs are called technicians. These professionals are most likely to enter positions in sectors such as construction, manufacturing, product design, testing, or technical services and sales. Those who pursue further study often consider engineering, facilities management, or business administration.⁹

ABET, however, concludes these explanations by stating “Of course, there is much overlap between the fields” (ABET 2012:1). A major problem with such definitions and explanations is that the position of technologists is not used by those in industry as we will see in the section on practice.

⁹ <http://www.abet.org/accreditation/new-to-accreditation/engineering-vs-engineering-technology/>

Many institutions that offer engineering and engineering technology programs use these definitions as a way of explaining the difference between the two programs on their departmental websites.¹⁰ Robison writes “The statements defining and pointing out curricular differences do not adequately reveal the differences that exist between these educational programs. Only upon close examination of the content, depth and level of each curriculum are the differences between the two curricula apparent” (1982:13). This inability of engineering technology to demarcate itself from engineering translates into difficulties when explaining what engineering technology is to prospective students and parents. Engineering technology’s boundary confusion and overlap with engineering is apparent only to academic and accrediting insiders within the field and thus “many students enter engineering or engineering technology without a clear perception of the differences between engineering and technology curricular and their respective employment opportunities upon graduation” (Robison 1982:25).

Expertise. Carlile connects knowledge with expertise/practice by describing knowledge as “localized, embedded, and invested in practice” (2002:442). Carlile (2002) suggests a pragmatic view of knowledge (localized, embedded, and invested in practice) and suggests that “knowledge that people accumulate and use is often ‘at stake.’ People and groups are reluctant to change their hard won outcomes because it is costly to change their knowledge and skills” (Carlile 2002:445).

The terms “applied” and “hands-on” are the traditional nomenclature of engineering technology. This applied nature of the technology programs manifests itself

¹⁰ See UNC-Charlotte <http://et.uncc.edu/about-us/engineering-vs-engineering-technology.html>; Wayne State University, Pittsburg State University <http://www.pittstate.edu/dotAsset/10561.pdf>

in laboratory experiences which play a major role in the educational process. Programs in engineering also contain laboratory courses but as Robison points out “those courses in engineering that contain laboratories show strong orientation toward experimentation or research. Technology education places laboratory emphasis on practical applications” (1982:14).

Power. Boundaries and power operate in a recursive configuration where boundaries have material and non-material effects on the distribution of power, prestige, and status (Bourdieu 1984) and a group’s power helps to maintain, strengthen, and expand their boundaries. Groups employ boundary work to exert or maintain power by 1) delegitimizing other groups through expulsive techniques of rhetorical ideological statements, 2) establishing a monopolistic control over a knowledge domain through expansion, and 3) protecting their own autonomy when threatened by external forces (Gieryn 1983:791-792). Burri (2008:36) argues that boundary work is used by groups to “accumulate symbolic capital within specific social fields.” These exertions of power are particularly noticeable during times of what Gieryn calls “credibility contests” (1983:786) and Amsterdamska terms “the legitimacy discourse” (2005:46) as groups attempt to justify their boundaries by laying claim to the authoritative and legitimate nature of their knowledge and practices.

The component of power in the boundary work between engineering and engineering technology, however, does provide demarcation between the two fields, with engineering clearly demonstrating the power differential over engineering technology. In addition to engineering being well known by the general public, a tangible example of this power differential is the requirements for taking the PE exam for state licensure as a

professional engineer. Furthermore, only 22 states in the U.S. allow individuals with engineering technology bachelor degrees to sit for their states PE licensure exam. In those states that do allow engineering technology graduates to take the PE exam, different criteria exist for those holding an engineering degree versus an engineering technology degree. For example, in the state of Georgia, a person who has an accredited engineering bachelor's degree may sit for the PE exam after four years of acceptable engineering experience. A person with a bachelor's degree in engineering technology must have seven years of acceptable engineering experience before sitting for their PE exam.

Engineering technology in the United States suffers from a lack of demarcation from engineering. Carr states quite frankly, that “the interface between engineering and engineering technology educational programs is not well defined. The career status of technicians, technologists, and engineers is not understood by educator or employer” (1979:6). This confusion with engineering has not abated over the years. Engineering technology suffers, as an academic and economic discipline, from a lack of clarity about what it is, what its graduates do, and confusion about the boundaries between it and its more powerful and well-known discipline, engineering.

2.1.4 Engineering Technology Summary

This study examines the role of engineering technology within the racially stratified structure of the field of engineering. This section examined the foundational framework for the creation and evolution of engineering technology. Engineering technology emerged from a perceived need for a more advanced technological workforce in the United States. The first convergence created such a need and the field of engineering responded.

Engineering technology's role within the field of engineering would act as a second tier between the engineer and technician/laborer. From its conception, engineering technology was perceived as supportive and subordinate to engineering and the mechanism of that control was clear. Engineering was a four-year degree and engineering technology was a two-year degree. All other controls within the field of engineering were contingent on that mechanism of control.

Then engineering technology usurped that mechanism of control and began offering four-year baccalaureate degrees. The usurpation of the primary mechanism of control created a need for engineering to exert social closure through other mechanism of control in order to "secure for itself a privileged position at the expense of some other group through the process of subordination" (Parkin 1979). Through these mechanisms of control (levels of mathematics, selectivity, licensing) as well as its size and reputation, engineering maintained its predominant role within the field. The move to four-year degree did provide engineering technology within the technical institutes with enrollment growth and delineation from junior college degrees, but it also placed the identity of engineering technology in a precarious position. Was it equal with engineering or did it remain subordinate? Simply using the mechanisms of controls mentioned (mathematics requirements, selectivity into programs, and licensing as a professional engineer) it appears that engineering technology does remain in a subordinate role to engineering. And yet in the practice and industry of engineering, graduates with engineering technology degrees are hired as engineers (NAE 2017:7,117-122). Because of the clear lack of research on engineering technology, this study aims to discover the role of engineering technology

within the field of engineering. The understanding of this role will help clarify the role engineering technology plays in the racially stratified structure of engineering.

2.2 African Americans within the Field of Engineering

African Americans have found it difficult to establish proportional numbers in science and engineering when compared to their white counterparts, especially white males. Many researchers and policy makers have decried this situation as unacceptable and untenable if the United States is to remain competitive in the global economy (Denson 2010; Maton 2012; Palmer 2011; Ong 2011). May and Chubin (2003:27) suggest that the United States could fully staff its STEM workforce if minority groups, including African Americans and women, were proportionately represented,

At the same time, STEM workers remain overwhelmingly white, male, and able-bodied, and the available pool of talented women, minorities and persons with disabilities remains significantly underutilized. Ironically, if individuals from these underrepresented groups were represented in the U.S. STEM workforce in parity with their percentages in the total workforce population, this shortage would largely be filled. Thus, more than ever, the nation must cultivate the scientific and technical talents of all its citizens, not just those from groups that have traditionally worked in STEM fields.

Yet African Americans remain disproportionately underrepresented in science and engineering education fields. This disproportionate environment is detrimental to the U.S. technological workforce, scientific discovery, and technological innovation and a cultural change is needed (Wulf 2008). While African Americans represent 13.3% of the resident population and 11.7% of the total U.S. workforce, they comprise 2.5% of engineering managers, 4.5% of engineers, and 7.0% of engineering technicians (NACME 2014).

Several studies indicate that women of color, facing the STEM double bind of gender and race, lag behind even white women and URM males (NSF 2015). Due to the lack of progress over time in correcting these disproportionate numbers, researchers have sought to understand reasons for this continued disproportionate distribution.

This section reviews previous research that helps explain the disproportionate distribution of African Americans in STEM and this population's struggle in achieving a sustainable presence within the field of engineering. The section begins with a broad focus on African Americans and STEM education and then focuses on research that deals specifically with engineering education. The first section reviews research that denotes positive stride made in finding African Americans a pathway into STEM fields including the role of HBCUs. The next section turns to obstacles that African Americans face when pursuing STEM degree programs. Such obstacles include high school preparation, engineering program selectivity, and their experiences within STEM higher education. The final section summarizes the findings and makes connection with the present study and its foci. This review begins with a summary of the debate between Booker T. Washington and W.E.B. Dubois concerning African Americans and their place within the higher education system in the United States. This debate lays a foundational framework for understanding how African Americans engage the U.S. system of higher education, especially the areas that pertain to technology.

An analysis of the literature on race and its relationship with science and engineering begins with understanding the relationships between African Americans and STEM education as seen through the lens of the Washington/DuBois debate. Booker T. Washington advocated a conservative, accommodating philosophy on the education of

African Americans that would not produce individuals who would compete with White Americans (Wharton 1992:26). Washington advocated an industrial education which had a limited education spectrum. This industrial education was “training in various domestic and trade skills within an authoritarian and religiously based environment would produce a Black who would fit into the lower end of the occupational structure and, more important, know his or her place among Whites and come to accept that place as proper” (Johnson 2004:66). This level of industrial education would guarantee to maintain black Americans as subservient and exploitive and create an employable working underclass. William E.B. DuBois objected to the “Tuskegee Machine,” Washington’s organizational infrastructure which included the Tuskegee Institute for black industrial education. DuBois believed that black Americans should be allowed to pursue the same educational pathways as white Americans. Unfortunately, the white dominant power structure in politics, philanthropy, and industry agreed with and supported Washington, and therefore, “for young black people who wished to become engineers, medical doctors, or other types of professionals, the way was blocked” (Wharton 1992:29). By 1930, industrial education for black Americans was seen as a “cynical political strategy, not a sound educational policy” and proved to be the “great detour” for Blacks from which they are just beginning to return (Winston 1971:683). The Washington-DuBois debate, therefore, established a trajectory of future pathways into STEM education and career field for minorities in general and black Americans in particular. This trajectory proved to be more of a hindrance and an obstacle than a launching pad.

The Tuskegee model flourished because it found fertile ground in the mindsets and worldview of White America due to the pervasive belief in “scientific” racism.

Watkins suggests that scientific racism “provided a foundation for both institutional and attitudinal racism in America” (2001:40). “Scientific” racism promoted the idea that the black race was deficient in mental abilities and inborn intelligence. Its promulgation provides the political and scholarly rationale for segregation until the 1954 Supreme Court ruling in *Brown v. Board Education* debunked the concept. Yet its historical impact on the infrastructure of education in the United States and its lingering influence on the world view of many White Americans continued to promote both institutional and attitudinal racism (Watkins 2001). Though segregation is no longer the official law of the land, it has been conceptually revised (note CRT’s idea of the mutability of racism) in the funding mechanisms of primary and secondary education (Reed 2001; Murray, Evans, & Schwab 1998; Kozol 1991). This inequity in funding leads to inadequate preparation for many Black students in science and mathematics, which will be discussed in section 2.2.2.

The reality of segregation, the second Morrill Land Grant Act (which required states that received federal funds for higher education to provide education for Black students), and the Tuskegee model lead to the formal formation of the HBCUs. Many of these institutions began as primary and secondary schools started by Black pastors and White philanthropists. The historical impact of HBCUs on the educational experience of African Americans is powerful but the impact that these institutions have had on the education of Black scientists and engineers is extraordinary (Slaughter, Tao, & Pearson 2015). And yet these extraordinary achievements in the production of engineers have largely occurred since the 1970s. In 1910, Howard University had the only engineering program at HBCUs and was the only accredited engineering program in 1960. By the early 1970s, six HBCUs had accredited engineering programs. Pierre (2015:16) noted

accreditation was accomplished with the assistance of the ASEE. Since then, Pearson (1985) found that HBCUs educated more than eighty-seven percent of the black Americans moving on to graduate level work in the STEM fields. Similarly for women of color, Leggon and Pearson (1997) found that HBCUs account for almost 70% of black female undergraduates in the STEM areas and 72% of black female students pursuing graduate education in the STEM disciplines. Fiegenger and Proudfoot (2013) found that HBCUs were 5 of the top ten producers of African American engineering Ph.Ds. Other studies have validated these research findings and affirmed the positive influence of HBCUs and minority serving institutions (MSI) on increasing the number of URMs in science and engineering (Palmer 2010; Perna 2010; Burrelli 2009; Whitten 2004).

2.2.1 Positive Outcomes related to African Americans and STEM Education

Several positives factors do exist for African Americans and STEM education and careers. Several studies attribute success in STEM education for URMs to supportive external constituents such as parents (Kaba 2013; Williams 2004; Smith 2003), private foundations, and governmental agencies (Smith 2003). Many studies attribute success to the personal drive of the individual, such as seeing the need for math preparation (Denson 2010; May 2003), using the double bind of race and gender as a motivator (McGhee & Martin 2011; Carlone & Johnson 2007; Ellington 2006; Ong 2005; Shain 2002), or seeking specific, personal interaction with professors, such as research projects, so that such mentors would view them as capable and allow for them to receive recognition (Carlone & Johnson 2007). Smith (2003:65) writes, “The spirit of prove-them-wrong syndrome is crucial in developing the coping mechanisms that manifest into positive vigor in spite of adversity.”

Many studies have noted that African Americans are drawn toward more applied, hands-on degree programs such as education (McDougal 2009; Fazarro & Stevens 2004; Durodoye & Hildreth 1995; Anderson & Adams 1992; Hale-Benson 1986). Tsui (2007) found that hands-on educational pedagogy and real life research experiences are key intervention strategies that increase the retention of minority students in STEM degree programs. Moore (2005) argues that black students perform better in mathematics when the pedagogy is based on real-life problem solving and culturally relevant cases. The employment of problem-based learning (a key component of engineering technology) leads to a significant improvement in the mathematic performance of black students (NAMCE 2011). The current study, however, challenges these assertions because its research indicates that both Caucasian and African Americans graduates of engineering technology programs who participated in the study's survey and interviews were drawn to engineering technology because of the hands-on, problem solving pedagogy of the programs. Such a finding suggests the applied pedagogy of engineering technology is a reason why many individuals chose engineering technology but it cannot be attributed to their racial category.

2.2.2 Obstacles facing African Americans in STEM including engineering

Many obstacles confront African Americans as they navigate the pathways of STEM education (Kaba 2013). These obstacles are embedded into institutional structures, general cultural discrimination, and individually held stereotypes, largely due to historical developments recounted in the first part of this section. As Slaughter (2015:2) notes, there are “countless other barriers that have prevented, or at least impeded, their entry as full participants in our nation's STEM enterprises include the sordid history of racism, discrimination and exclusion encountered, and inadequate – and in some cases nonexistent

– educational and employment opportunities.” This study focuses on several obstacles such as 1) the inadequate preparation for and exposure to science and engineering pathways at the secondary educational level, 2) the selectivity/rigor/weeding out process, and 3) the isolation and stereotyping of African Americans within the culture of science. These obstacles make it difficult for African Americans to develop a technological identity while at the same time that they maintain their racial identity (Hurtado 2009:210).

Black students find that their exclusion from STEM fields begins at the middle and high school years with inadequate preparation for the STEM disciplines, especially their preparation in math, and the lack of exposure to possibilities in science and engineering by teachers and counselors. Preparation in mathematics is the key to success in engineering. A student who is adequately prepared and feels confident in their mathematical abilities is significantly more likely to pursue and succeed in the education and field of engineering (Pearson and Miller 2012). Pearson and Miller (2012) also indicate that the number of math courses taken during a student’s high school career is also important because it allows the student in advance into calculus during high school. Chen (2009) found a strong correlation between the receiving of an engineering degree and the number of calculus courses taken during a student’s high school career. Austin (2010) demonstrates that the correlated relationship between positive self-efficacy in mathematics and engineering applies directly to black students as well. The black students’ confidence in their math and science abilities of directly correlated with their desire to pursue an engineering degree. Many studies, however, highlight the inadequate preparation that Black students receive in mathematics (NSB 2012; Smith 2003:62-63; Denson 2010:71). This lack of preparation in mathematics, coupled with low expectations of teachers and counselors regarding their

academic abilities, lead to lower standardized test scores as well as lower participation in advanced scientific courses than their White and Asian counterparts (Malcom-Piqueuz 2013; Maton 2012). Many black students are educated in school systems with low tax income and, therefore, are educated in inadequately equipped secondary facilities, i.e. labs (Smith 2003:63). Denson (2010:62,71) argues that black students lack of exposure to engineering as a career pathway by teachers and counselors prevent them from obtaining the necessary information in order to make an informed decision about engineering as a career choice.

Because many black students are underprepared in mathematics, they encounter difficulties in gaining entry into science and engineering programs. For those that are admitted, their inadequate preparation hinders their continuation. Many studies confirm that minorities are as equally likely to pursue education in STEM fields as the dominant group (Beasley 2012; Ong 2011; Kaba 2013; Garrison 2013). Though the willingness is present, black students find it difficult to gain acceptances into science and engineering programs because of lower standardized test scores and their lack of advanced science and math courses. Slaton (2010) examines reasons behind the low number of African Americans in American engineering. The substantive findings are that engineering education in the United States has 1) capitulated with the historical commitment to a two-tiered economic system where African Americans were assigned to the lower caste positions of repairmen, mechanics, or technicians and 2) a tension between the goals of diversity and selectivity in U.S. engineering schools.

The first finding resonates with Wharton's historical review (1992) and provides the historical foundation which creates the struggle between black students and rigorous

engineering admission selectivity. Slaton states that engineering is “a body of knowledge and practice rooted . . . in a racially stratified worldview generally resistant to radical social change” (2010:80). Her main argument that the problem of low numbers of African Americans in engineering is that US engineering schools find conflicting tension in their goals of increasing diversity and maintaining rigorous selectivity. Slaton argues that the selectivity goal wins out over increasing diversity due to the engineering schools’ concerns about maintaining their academic reputation (2010:211). Their reputations impact (and are impacted by) recruitment, outside accreditation, and research funding. The recruitment of students who have been “highly qualified” by the standardized assessment instruments of GPA and SAT/ACT scores adds to an institution’s reputation. Yet Slaton (2010:10) points out that the idea of meritocracy in engineering encourages the maintenance of existing structures in STEM fields which regulate admission through selectivity. The external pressures from accrediting bodies and research funding agencies to conform has led many institutions to abandon their desire to increase diversity in order to focus on structures that maintain accreditation and increase research funding (2010:211).

This desire for increased reputation also caused institutions to eliminate remedial courses. Thus engineering institutions continue to impose stricter and more rigorous academic requirements, both in admission standards and course work, thus excluding many black students who are not privileged with strong high school preparation. Slaton concludes that the concern among engineering program over the perception of “lowering standards” has caused academic engineering to restrict its acceptance into engineering degree programs in the name of rigor. Any yet, she argues, rigor/selectivity is based on a few variables such as standardized test scores and GPA in advanced science and math

courses. Slaton suggests that engineering degree programs need to become more flexible and expansive in regards to what attributes and education it takes to produce a good engineer.

The obstacles continue once acceptance into science and engineering degree programs is obtained. Beasley points out that black students are as equally proportionate to white students in seeking STEM educational degrees, but “minorities leave STEM at a higher rate due to the stereotype challenges” (2012:442). Garrison (2013:362) found significant “differential graduates rates at both the undergraduate and graduate level (along with postdoctoral plans for Blacks) have the greatest impact on the underrepresentation of Blacks, Hispanics, and American Indians/Alaskan Natives in doctoral level careers in science and engineering.” In comparison, Borous-Hammath (2000) found that Asian/Pacific Islanders and Whites complete STEM degrees at much higher percentage than Blacks, Native Americans, or Hispanics. In the study, 86.3% of the Asian/Pacific Islanders and 77.3% of Whites who started the degree program graduated within six years compared to 58.9% for Blacks, 57.7% for American Indians/Alaskan Natives, and 62.9% for Hispanics, thus increasing the gap between these dominant groups and the URM (2000:361). Several researchers have found that this disproportionate distribution continues at the graduate level (Pearson 1997; Leggon & Pearson 1997; Ong 2011; Brown 2000). Several studies suggest that black students who seek education beyond the undergraduate level are funneled into education and away from science and engineering (Kulis 2000; Slaton 2010).

Personal and professional isolation while pursuing a STEM degree program due to stereotypical attitudes about URMs and science emerges as one of the primary obstacles to

retention and STEM degree completion (Denson 2010; Justin-Johnson 2004; Brand, Glasson, & Green 2006). Hurtado et al. (2009:193) insist that culture of STEM inhibits the confidence level of URM for doing science/engineering. This level of confidence, they assert, is essential for an individual to develop an identity as a scientist or engineer. These stereotypical attitudes that black students cannot perform as well as white males in science and engineering have become internalized (Dickey 1996) and that students of color, especially women of color, are not recognized as legitimate members of the STEM community (Carlone & Johnson 2007). If black students pursue STEM degree programs, this “stereotype threat” manifests itself in the form of performance anxiety (Beasley 2012). These students have to perform at a much higher level to prove themselves by performing extra work to gain acceptance (McGhee & Martin 2011; Ong 2002:43) by professors who already hold, due to stereotypical attitudes, expectations that black students are expected to fail (Borouh-Hammath 2000:109; Varma 2006; Carlone & Johnson 2007). Numerous studies demonstrate that this isolation is enhanced for black students and the stereotypical attitudes in STEM is affirmed by the lack of role models and mentors of color (Leggon 1997; Maton 2012; Fleming 2008; Beasley 2012; Perna 2010; Ong 2012; Smith 2003). The isolation caused by this stereotype threat creates difficulty in transitioning into the culture of science (Reyes 2011) and attributes to the smaller number of URMs, especially women of color, moving on to graduate work (Ong 2005; Brown 2000). The isolation caused by the stereotype threat creates an environment in which only the select few can “successfully navigate exclusion and their unique representation in science on their path toward becoming a scientist” (Hurtado 2009:193). Black students in science and engineering quickly discover they are numerically outnumbered compared to their white

and Asian counterparts and that they must “prove” themselves worthy of an identity as a scientist or an engineer to faculty and peers who regard their abilities as limited or inferior based on stereotyped perspectives. Therefore one can understand why isolation continues to be major factor in the attrition of African Americans from science and engineering.

In sum, the review of the literature and research suggests that mechanisms of control and social closure employed by engineers to maintain their high status in the stratified U.S. society creates a culture of inequality in the field of engineering through the auspices of academic selectivity, educational credentials, and licensing structures. The research in underrepresented minorities in STEM fields highlights a number of these mechanisms of control and closure. Limited educational resources at the secondary level impeded black students in their mathematical and scientific intellectual development thus placing them at a disadvantage in being accepted into engineering programs and progressing through those programs. Mathematics and other engineering concepts taught through abstract pedagogies are not conducive to the learning styles of many African Americans. Black students face isolation within engineering programs due to the lack of peers or role models within the programs. Because of their token levels, many underrepresented minorities face blatant discrimination. Engineering’s desire to remain a high status academic discipline and profession creates barriers/mechanism of control and closure, such as selectivity, rigor, and a sink or swim attitude, which impeded the entry and success of underrepresented minorities.

2.3 Summary

This review draws on the limited body of literature related to engineering technology and on the more diverse body of research related to African Americans and STEM/Engineering education. From this review, several components of engineering technology are established: its historical role, its pedagogical perspective, and its struggle with identity. The historical role of engineering technology is clearly established within the stratified structure of engineering. From its conception, engineering technology has embraced the pedagogical perspective of applied, hands-on education. Because of its mediating role between the engineer and the laborer/technician, engineering technology struggled with its identity and delineation of its place in the hierarchy. This identity crisis is exacerbated by its transition into the baccalaureate arena, once the sole domain of engineering.

This review highlighted the numerous obstacles that impeded black students' pursuit of STEM/Engineering education, including lack of exposure, poor mathematical preparation, financial struggles, peer and faculty isolation, and discrimination. This review highlights a number of mechanisms of control such as the importance of mathematics, admission selectivity, financial considerations in pursuing a degree, instructional pedagogy, and licensing. This study aims to understand the connections between engineering technology and African Americans and the role that engineering technology plays as a pathway for African Americans into the field of engineering. This study seeks to contribute to the myriad of research and debate on the best practices for attracting, retaining, and graduating more black students into the field of engineering. The next chapter presents the methodology which will guide this study; electronic surveys, semi-

structured interviews, and data/content analysis are described in detail, and the methods of analyzing the data are presented.

CHAPTER 3. METHODOLOGY

This chapter provides an overview of the methods and research procedures utilized in this dissertation. This chapter provides an overview of the purpose of the study, the selection of methodologies, selection of data sets, institutions, and survey/interview participants, and how the research methodology provides for the appropriate collection of data. The chapter then provides a more in-depth explanation of the primary methodologies of the study: data analysis of national and institutional aggregate data, electronic surveys, and semi-structured interviews. I review how the data are extracted on degrees granted from Integrated Postsecondary Education Data System (IPEDS)¹¹ for engineering and engineering technology programs within the United States. The chapter then reviews the selection of institutions used to explore the current role of engineering technology within the field of engineering. I review how participants in engineering technology understand engineering technology and its role in engineering. The chapter details the administration of an electronic survey to engineering technology faculty and alumni of the selected institutions. It also discusses the selection and process for conducting semi-structured interviews. The chapter reviews the collection of comparative data: curriculum requirements and criteria for taking the PE exam. This comparative data includes curriculum requirements at engineering and engineering technology programs in four states as well as the criteria used by all 50 states to determine who is eligible to take the PE exam in order to be considered a licensed engineer in that particular state. The chapter then

¹¹ Information on the IPEDS database can be found at <http://nces.ed.gov/ipeds/datacenter/datafiles.aspx>.

reviews the procedures used in data analysis of both the quantitative and qualitative data and concludes with a discussion of data and analysis credibility.

3.1 Study Purpose and Overview of Methods

The study explores the role of engineering technology within the racially stratified structure of engineering and whether engineering technology is a viable pathway for African Americans into the field of engineering. This study employs a multiple data source framework that combines quantitative and qualitative methodologies, which are used as tools of discovery, in order to produce a holistic examination of the subject matter. The mixed-methods collecting of both quantitative and qualitative data creates a “deep data cut” for comparison with the others and the larger field of engineering in the discovery analysis. Suchman writes “different ‘apparatuses of observation’ enable different, always contingent, subject-object cuts that in turn enable measurement or other forms of objectification, distinction, manipulation, and the like within the phenomenon” (2007:267-268). Table 3 provides an overview of the methods and subjects which are studied; each is described in more detail in the following sections. The various methodologies were employed simultaneously over a fourteen month period from October 2015 to December 2016. The latest data sets as of July 2016 were obtained from IPEDS. These data sets include 2011-2015. The primary data set to be used will be 2014 which has the most complete and verified data. The data set from 2015 contains only provisional data. The IPEDS data sets includes the graduation information on engineering and engineering technology programs by race and gender.

Table 3 Mixed Method Analysis¹²

Data Sets	Surveys	Semi-structured Interviews	Aggregate Data
Engineering and Engineering Technology Graduation Data from IPEDS ¹³ (2014)	ET Faculty members at Southern Polytechnic (11) and Purdue (27)		Curriculum Requirements from Engineering and Engineering Technology programs in Georgia, Indiana, Texas, and New Jersey ¹⁴
	ET Alumni at Southern Polytechnic (184) and Purdue (450)	ET Alumni at Southern Polytechnic (12) and Purdue (9)	State Criteria and Requirements for the Professional Engineering (PE) exam.

Electronic surveys were administered between October 2015 and December 2015. Surveys were administered to engineering technology faculty and engineering technology alumni from Southern Polytechnic State University (SPSU) and Purdue University (Purdue). Semi-structured interviews were conducted with selected engineering technology alumni from the same two institutions mentioned above. Curriculum requirements as of March 2016 for all engineering and engineering technology programs

¹² Number of participants are in parentheses.

¹³ IPEDS is the primary data collection programs on postsecondary education by the National Center for Education Statistics (NCES). NCES is the primary federal entity for collecting and analyzing data related to education in the U.S. and other nations. NCES is located within the U.S. Department of Education and the Institute of Education Sciences. See <http://nces.ed.gov/ipeds/>.

¹⁴ The selection of these particular states will be discussed in the following sections.

at accredited institutions in Georgia, Indiana, Texas, and New Jersey were collected. The study collected the criteria and requirements for taking the PE exam from all 50 states. The study received approval from the Georgia Institute of Technology's Institutional Review Board to conduct surveys and semi-structured interviews (IRB Protocol 14261).

3.2 Integrated Postsecondary Education Data System (IPEDS)

The study uses the IPEDS national data sets to examine and compare the percentage of African Americans who graduated from engineering and engineering technology programs. This national data set allows the study to develop a comprehensive picture of the racially stratified field of engineering in the United States. The information contained in this national data set was disaggregated by race and gender. The data are analyzed at the national, state, and the institutional level.

The IPEDS data were retrieved from the Department of Education, National Center for Education Statistics. The file contains the number of awards by type of program, level of award (certificate or degree), first or second major and by race and gender. Type of program is categorized according to the Classification of Instructional Programs (CIP), a detailed coding system for postsecondary instructional programs. The primary data set (2014) used covers all awards granted between July 1, 2013 and June 30, 2014. Other data sets used are from 2011-2013 and 2015. The 2015 data set is classified currently as provisional data by IPEDS. The data sets contains multiple records per institution. Each record is uniquely defined by the variables IPEDS ID (UNITID), classification of instructional program (CIPCODE), first or second major (MAJORNUM) and award level (AWLEVEL). Each record contains the total awards, awards by gender, and the total

awards and awards by gender and race. Provisional release data have undergone all NCES data quality control procedures. Data are imputed for nonresponding institutions. Final release data include revisions to the provisional release data that have been made by institutions during the subsequent data collection year. The most recent final release data is the 2014 information and this data set was used. The CIPCODES 14.0 to 14.999 are classified as engineering programs and the CIPCODES 15.0 to 15.999 are classified as engineering technology programs. The recent publication on engineering technology in the U.S. by the National Academy of Engineering indicates the wide range of programs offered under the heading of engineering technology (2017:51-57) and the difficulties that it creates when attempting to describe engineering technology.

The only manipulation of the data is the combining of the following “for profit” institutions’ campuses within a state into a single institution for that state: ITT Institute and DeVry Institute. The reason for this combining are 1) these institutions have multiple campus sites within a state and 2) the institutions operate under a more centralized institutional model.

3.3 Institutional Sites

Two institutions were selected to serve as institutional sites. The primary criteria for selection was they must be one of the top ten institutions that graduate the most engineering technology graduates. The secondary criteria for selection were that the institution offer engineering degrees and were willing to participate in the study. I obtained a list from ASEE of the institutions with the largest number of engineering technology graduates. The researcher then choose five of the top producers of engineering technology

graduates that also awarded engineering degrees. These institutions were Purdue (IN), SPSU (GA), University of Houston (TX), Prairie View A&M (TX), Rochester Institute of Technology (NJ), and Texas A&M (TX). The researcher contacted each of the deans from these institutions in an email describing the study and asking for their cooperation. All of the deans initially agree to cooperate and referred the researcher to their respective Institutional Review Boards (IRB) offices. The Purdue, SPSU, Prairie View A&M, and Texas A&M IRB offices approved the project because none of their faculty were involved in the administration of the research. The University of Houston and the Rochester IRB offices required a formal submission of information. The IRB offices at Houston and Rochester did not approve the project because of a backlog of projects. Texas A&M was dropped from the selected universities because the researcher was unable to obtain alumni email addresses from their alumni office. Unfortunately, the response rate of returned alumni surveys from Prairie View A&M was extremely low (0.8%) and, therefore, Prairie View was dropped as well. Therefore, Purdue and SPSU remained as the institutional sites. The study recognizes that two sites provide a limited sample and the conclusions drawn from the data analysis from these sites is not representative of the overall state of engineering technology in the U.S. This limited sample is due to the financial constraints of the researcher. The study hopes the findings and conclusion will provide direction for future research.

3.3.1 Electronic Surveys

Electronic surveys were administered to engineering technology faculty and alumni at the two selected institutions. The surveys included both closed and open ended

questions¹⁵. Crewell (2011:201) writes, “The advantage of this type of questioning is that your pre-determined closed-ended responses can net useful information to support theories and concepts in the literature. The open-ended responses, however, allow for more elaboration on the question.” The closed ended questions on the survey were developed in order to obtain a clear picture of the status and role of engineering technology as perceived by those who teach engineering technology and those individual who have obtained an engineering technology degree. The study intentionally limited the participants to those individuals who were associated with engineering technology. The study does not seek to understand how engineering technology is perceived by those outside this particular field. Research on such external perception of engineering technology needs to occur in future research. The open ended questions allowed the participants to either explain answers to closed ended questions or expand on a particular question. A description of each group of participants, survey questions, and recruiting methods will be described in more detail in the following sections. A pilot survey (N=24) was conducted to assess the validity of the study instrument.

None of the survey participants were compensated for their participation. The first page of the survey contained instructions for taking the survey as well as IRB required information. This page served as a consent form outlining the purpose, risks, and benefits of the study (Appendix A). The page also described how participant confidentiality would

¹⁵ The electronic surveys were administered through the proprietary software service SurveyMonkey. SurveyMonkey is an online development cloud-based company, founded in 1999 by Ryan Finley. SurveyMonkey provides free, customizable surveys, as well as a suite of paid back-end programs that include data analysis, sample selection, bias elimination, and data representation tools. In addition to providing free and paid plans for individual users, SurveyMonkey offers more large-scale enterprise options for companies interested in data analysis, brand management, and consumer-focused marketing. Obtained from <https://en.wikipedia.org/wiki/SurveyMonkey>. Survey Monkey takes user security seriously. Its security and privacy statements can be found as <https://www.surveymonkey.com/mp/policy/security/>.

be maintained. The page contained contact information of the researcher and the contact information for the faculty advisor should participants have any additional questions concerning the research. By continuing with the survey, the participants provided their consent in being part of the study.

3.3.1.1 Engineering Technology Faculty Surveys

The faculty survey was administered to all full-time engineering technology faculty at the two selected institutions (Appendix B contains both the faculty and alumni survey

Table 4 Faculty Survey Information

	Gender	Race	Degree Obtained	Rank	Tenured	Time at Institution (yrs)
Purdue N=27	F=6 M=17 NR=4	B=1 H=0 As=4 O=0 W=18 NR=4	Doctorate=12 Masters =11 NR=4	Prof=12 Assoc=7 Assist=8 Lect=0 NR=0	Tenured=18 Tenure Track=4 Not Tenured=5 NR=0	1-5=12 6-10=3 11-15=1 16-25=6 >25=5
SPSU N=11	F=0 M=10 NR=1	B=2 H=0 As=2 O=0 W=6 NR=1	Doctorate=6 Masters =4 NR=1	Prof=1 Assoc=4 Assist=4 Lect=1 NR=1	Tenured=4 Tenure Track=2 Not Tenured=3 NR=2	1-5=4 6-10=0 11-15=5 16-25=0 >25=2

questions). The survey questions focused on the status, role, and future of engineering technology as well as efforts by the institution for recruiting and retaining minority students. The survey also requested such demographic information as highest degree obtained, faculty, rank, tenure, time at institution, gender, and race.

Table 4 includes information on the respondents by institutions as well as the response rate based on the initial number asked to participate. The administration of the survey to engineering technology faculty varied by institution. At SPSU, I (formerly an administrator at this institution) obtained a listing of all engineering technology faculty and their emails from the Dean's Office. The researcher then sent an email to 17 engineering technology faculty members (recruitment email included in Appendix C). After two weeks, I sent another email asking all faculty who had not participated in the survey to complete the survey. The email was sent to 17 full-time faculty members at SPSU. Eleven responded to the survey which is a 65% response rate.

At Purdue, I first met with the dean of the College of Technology and program director of the engineering technology school to discuss the research and obtain their cooperation. The program director for engineering technology assigned a member of the ET faculty to assist me with the distribution of the email. The email (Appendix C) was sent to 36 full-time faculty members at Purdue. Twenty-seven responded to the survey which is a 75% response rate. The study acknowledges that the Ns for faculty were low due to having only two institutions in the sample.

3.3.1.2 Engineering Technology Alumni Surveys

Table 5 contains the alumni survey demographic information including breakdown by institution, gender, race, and degree. The administration of the survey to engineering technology alumni varied by institution. At SPSU, the researcher obtained a listing of all engineering technology alumni who had email addresses from the Office of University Advancement. The researcher then sent an email to a randomly selected

number of these alumni (email in Appendix C). After two weeks, the researcher sent another email asking the alumni who had not participated in the survey to complete

Table 5 Alumni Survey Information

	Gender	Race	Degree Obtained
Purdue (N=450)	F=29 M=306 NR=115	B=31 H=0 As=6 O=8 W=272 NR=133	Associate = 6 Bachelor = 243 Masters = 80 Doctorate = 4 NR= 117
SPSU(N=184)	F=10 M=136 NR=38	B=22 H=1 As=1 O=1 W=123 NR=36	Associate = 1 Bachelor = 111 Masters = 32 Doctorate = 0 NR= 40

the survey. Another email was sent two weeks later. The email was sent to 1674 alumni at SPSU. The researcher received 855 undeliverable email addresses which reduced the valid number of participants to 819. One hundred and eight-four responded to the survey which is a 23 % response rate.

At Purdue, the same faculty who assisted with distribution of the email to faculty member also assisted with the distribution to Purdue ET alumni. The faculty member experienced initial difficulty in obtaining the cooperation of the Alumni Office at Purdue. I spoke with the alumni director about the purpose of the research. Cooperation of the alumni office was secured. The alumni office provided a list of ET alumni and their emails to the ET faculty member. The faculty member then distributed the email. After two

weeks, the faculty member sent another email asking all alumni who had not participated in the survey to complete the survey. The email was sent to 4075 alumni at Purdue. The researcher received 1651 undeliverable email addresses which reduced the valid number of participants to 2424. Four hundred and fifty responded to the survey which is a 19% response rate. The current study acknowledges that the response rate from the alumni surveys at both the institutions were low. The study made every attempt to send follow-up emails but with limited financial resources this proved difficult.

3.3.2 Semi-Structured Interviews

Unstructured interviews were conducted with 21 alumni from SPSU (N=12) and Purdue (N=9). The survey to the ET alumni asked if the participant would be willing to participate in a telephone interview and over 50% of the respondents indicated they would be willing to participate. The researcher did seek to interview as many African Americans as possible. Of the thirty alumni who were sent an email about participating in the study, twenty-one interviews were completed (70% response rate). Of the 21 interviews, 17 interviewees were male and 4 interviewees were female. Eight of the interviewees were African-Americans while the remaining 13 were Caucasians. The study acknowledges the low number of African American in the interview section but every effort was made to recruit other African American participants. The intent of these interviews was to understand how graduates of the programs viewed their undergraduate educational experiences and how they fared in the working world of engineering. The interview questions included: a) personal and educational background; b) experience during their undergraduate engineering education, and 3) how their degree program help or hindered them during their engineering career. See Appendix D for a list of interview questions.

Interviews were audio-taped and transcribed by the researcher. All identifying names were removed.

3.4 Comparative Data

In order to provide a more comprehensive view of engineering technology programs and how they compare to engineering programs, the following data were collected: the mathematical and science curricular requirements of electrical and mechanical programs in selected engineering and engineering technology program and the criteria for taking the PE exam. The math and science degree requirements for graduation from all mechanical and electrical engineering and engineering technology programs in four states¹⁶ were examined to determine differences between engineering and engineering technology curriculum requirements. This information was obtained from each institution's catalog. If an institution had an IPEDS designated program in engineering technology program but those programs were not in the electrical or mechanical discipline, then their mathematical and science requirements were noted.

The PE license is highly regarded in the field of engineering as a symbol of occupational excellence. Its primary benefit is that “a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients.”¹⁷ Each state regulates the criteria for taking the PE exam and those criteria vary by state. The primary criteria in all states is the

¹⁶ The four state were Georgia, Indiana, New Jersey, and Texas and correspond to the original institutional sites selected.

¹⁷ <https://www.nspe.org/resources/licensure/what-pe>

obtainment of a 4-year degree from an ABET-accredited program¹⁸. Some states allow graduates with degrees in engineering technology to take the PE exam. The criteria for taking the PE exam was retrieved for each state. This information was obtained by visiting each state's licensing board webpages and accessing the criteria.

3.5 Data Analysis

3.5.1 Quantitative Analysis.

The quantitative data includes survey items and the IPEDS data on degrees granted. Statistical analysis such as t-tests and regression analysis are conducted on survey data to determine similarities and difference between and within groups (faculty, alumni, race, and gender). Statistical analysis such Pearson's Chi-Square Test of Independence are conducted on the degrees granted between the engineering and engineering technology programs to determine if any significant differences exist between these programs at the national, state, and institutional level. A comparison is made of the admission criteria and curricular requirements of the engineering and engineering technology programs at selected institutions to determine the similarities and differences between the two types of programs. This information allows the researcher to determine the selectivity and rigor of these programs.

¹⁸ ABET is the educational accrediting body for U.S. college and university programs in the disciplines of applied science, computing, engineering and engineering technology at the associate, bachelor and master degree levels.

3.5.2 *Qualitative Analysis.*

The study draws on the process developed by Strauss and Corbin (1998) where transcripts of the interviews, surveys' open-ended narratives, and documents are analyzed in sentences and groups of sentences. Ideas or concepts are coded and these codes are then categorized into thematic concepts. Thematic analysis is a qualitative form of analysis and is defined as a process-oriented approach that involves using a systematic technique of identifying and coding themes (Creswell 2011). The thematic analysis involves a recursive series of noticing, collecting, and thinking about the data (Creswell 2011:243). This type of analytic process was not focused on gross analysis and summarization of a category of the data. Rather, it emerged out of preliminary coding and followed the prescription of working with a smaller amounts of data, and a lot of right-brain creativity. These thematic concepts then connect to the central or core ideas of the research (Strauss and Corbin 1998) which would be the 1) stratification between engineering and engineering technology and 2) stratification of African Americans in engineering and engineering technology. These central or core ideas then come together to determine if engineering technology acts as a gateway or a gatekeeper for African Americans in the field of engineering.

3.5.3 *Credibility, Consistency, and Transferability*

All research is concerned with producing knowledge that is valid and reliable. Concerns about validity and reliability have plagued qualitative research. Merriam (2009) suggests that the issues of validity, reliability, and generalization should be reframed within qualitative research to better match the data that are collected and analyzed. Merriam

suggests that validity should be reframed as credibility, reliability should be reframed as consistency, and generalizability should be reframed as transferability (2009:213).

Credibility is based on the presumption that qualitative research assumes reality to be multidimensional and dynamic, not a single, fixed phenomenon. Credibility asks if the findings from the research are “credible given the data presented” (Merriam 2009:213). A means of providing credibility is triangulation. The concept of consistency, as opposed to reliability, the object of the qualitative research and analysis is to make sure that, “given the data collected, the results make sense – they are consistent and dependable” (Merriam 2009:221). Several mechanisms will be used to ensure credibility and consistency: triangulation and member checks. Triangulation refers to the process of contrasting conclusions “using multiple sources of data” drawn from multiple data collection strategies and data sources to inform a study’s findings (Merriam 2009:216). Since the study focuses on survey and interview data from two institutional sites, curriculum data from five states, and multiple methods of data collection, then triangulation can be accomplished (Creswell 2011:259). The study employs member checking, a process where emergent findings and researcher’s interpretations are shared with participants of the study for verification (Creswell 2011:259).

CHAPTER 4. DESCRIPTIVE DATA AND ANALYSIS

This chapter presents and analyzes descriptive data that contains 1) the ethnic breakdown of degrees granted for all engineering and engineering technology programs in the United States and 2) curriculum and PE exam requirements to help delineate the similarities and differences between engineering and engineering technology. The data on degrees granted demonstrate that Black students graduate at a higher percentage from engineering technology programs than from engineering programs, even from programs housed at the same institution. The data on degrees granted indicate that historically black institutions continue to produce a significant percentage of African American engineers. The curriculum requirements confirm that engineering and engineering technology programs focus on the same engineering content but differ in their mathematical and scientific requirement expectations. The curriculum requirements data also demonstrate the spectrum of mathematical and scientific requirements that exist across engineering technology programs. The data on requirements needed to take the PE examination differ from state to state and demonstrate the disadvantages for those who have engineering technology degrees.

The data from the IPEDS survey provides a descriptive picture of engineering and engineering technology in the United States.¹⁹ Based on the IPEDS data, 556 institutions offer engineering bachelor degrees, 128 institutions offer both engineering and engineering

¹⁹ Even though IPEDS only provides degrees granted and not enrollment data, IPEDS is a better database to determine an overall picture of the engineering technology in the United States because it is more comprehensive. IPEDS includes all engineering technology degree programs at the associate, baccalaureate, masters, and doctoral levels. The 2014 IPEDS data set was used. ASEE offers enrollment and graduation data but this database only includes membership institutions. A large number of associate programs and some baccalaureate programs are not members of ASEE.

technology bachelor degrees, and 127 institutions offer only engineering technology bachelor degrees²⁰. An additional 1912 institutions offer two-year associate degrees in engineering technology. The focus of this study, however, is on bachelor degrees in engineering and engineering technology.

An analysis of the institutions that offer both engineering and engineering technology (N=128) indicate that these institutions are primarily public comprehensive universities (N=102) with only 10 state flagship institutions offering engineering technology. Many of these public comprehensive institutions are designated as agricultural and mechanical (A&M) or technological institutions. Of the institutions that offer only engineering technology degrees (N=127), 73 are public comprehensive universities, 26 are state colleges, and the rest are divided between private institutions and institutes. No state flagship institution offers only engineering technology degrees. There are 25 HBCUs that offer engineering programs and 25 that offer Engineering technology programs. Sixteen of the 25 engineering programs are ABET accredited, while 9 of the 25 engineering technology programs are ABET accredited. Eight HBCUs offer only engineering programs, 15 HBCUs offer both engineering and engineering technology programs, while 10 HBCUs offer only engineering technology. If you remove the HBCUs from the state by state comparisons, the percentages for both engineering and engineering technology

²⁰ The researcher chose to count DeVry Institute and ITT Technical Institute as a single entity though they are listed in the data set as having multiple sites. This entity will be treated as a single institution with multiple satellite campuses. To note, since these data was produced, ITT Technical Institute has ceased to operate.

programs does decrease but does not change the ratio between engineering and engineering technology nationally or by state.²¹

Engineering technology degree programs reflect the disciplines found in the engineering programs such as civil, mechanical, electrical, and industrial but do have more industry or skill focused majors than those found in engineering such as Quality Control and Safety Technologies or Electromechanical Instrumentation and Maintenance Technologies.²² Electrical (16.2%), industrial (15.6%), and mechanical (12.8%) related engineering technology degree programs produced the most graduates in 2014. Engineering technology programs granted 16,465 bachelor degrees in 2014. In comparison, engineering programs granted 94,293 bachelor degrees which means that engineering technology graduates made up 15% of all engineering-related degrees in 2014.

4.1 Degrees Granted

Graduation or degrees granted is the best indicator of success in higher education. In 2014, institutions in the United States graduated 110,758 individuals with a bachelor degree in engineering related fields. Figure 2 shows the distribution of all engineering and engineering technology degree over the past five years.²³ The top three engineering disciplines represented with degrees in engineering for 2014-15 were mechanical, civil, and electrical, while the top three disciplines represented with engineering technology

²¹ South Carolina does prove to be an anomaly in this case. The percentage of ET graduates decreases from 39% to 19% when HBCU engineering technology graduates are removed. The 19% still is three times the percentage of black engineering degree graduates.

²² For a more thorough analysis of these multiple skill- focused majors see the NAE publication on engineering technology (2017:8, 53-57).

²³ Please note that 2015 data is still provisional.

degrees were electrical, industrial, and mechanical. African Americans and Caucasians were equally distributed among these top disciplines.

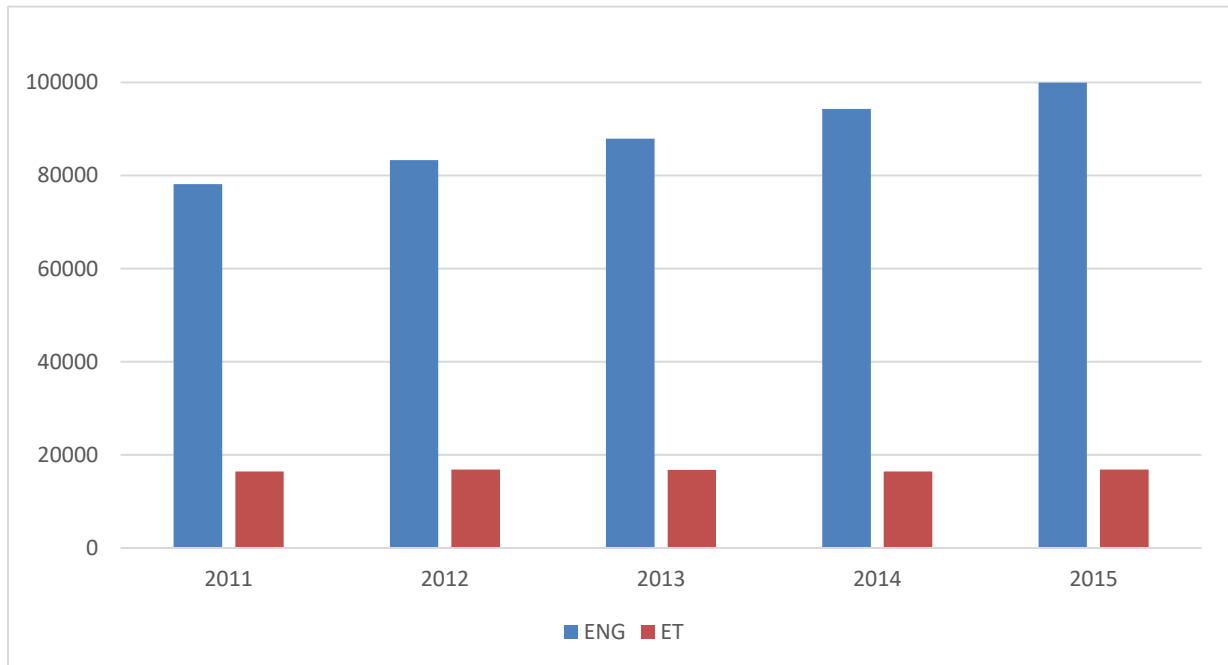


Figure 2 - ENG and ET degrees granted 2011-2015

Based on the percentages, engineering technology programs graduate a higher percentage of African Americans than engineering programs. Table 6 outlines the breakdown of race/ethnic groups by program including total graduates and percentages.

Table 6 Bachelor degrees granted in engineering and engineering technology programs 2014

	Engineering**		Engineering Technology**		General Population***
	N	%	N	%	%
Black	6930	3.98	2950	9.17	13.3
Asian	19917	11.44	1244	3.87	5.6
Hispanic	15549	8.93	2762	8.59	17.6

Other*	3890	2.23	712	2.22	1.9
White (Non-Hispanic)	107574	61.77	22034	68.52	61.6
Non Resident Alien	13564	7.79	1194	3.71	NA
Unknown	6716	3.86	1260	3.92	NA
* Native American, Hawaiian/Pacific Islander, and Two or More Ethnic Categories **Source: IPEDS *** U.S. Census Bureau 2015 - https://www.census.gov/quickfacts/table/PST045215/00					

The Pearson Chi-square Test of Independence (Table 7) indicated strong evidence of differences in the race of students of completing these two degree types using data on a national level ($p < .0001$). Based on the cell chi-square, Black and Asian ethnicities show

Table 7 Race by ENG/ET program - Pearson's Chi-Square

		AS	B	H	NRA	O	UNK	W	Total
ENG	Count	10283	3577	8982	7665	2622	3318	57846	94293
	Overall %	9.28	3.23	8.11	6.92	2.37	3.00	52.23	85.13
	Expected	9314	4429	8956	7089	2598	3433	58474	
	Cell Chi^2	100.88	163.78	0.07	46.77	0.21	3.82	6.75	
ET	Count	657	1625	1538	662	430	714	10839	16465
	Overall %	0.59	1.47	1.39	0.60	0.39	0.64	9.79	14.87
	Expected	1626	773	1564	1238	454	599	10211	
	Cell Chi^2	577.72	937.99	0.42	267.90	1.23	21.91	38.68	
Total		10940	5202	10520	8327	3052	4032	68685	110758

Tests

N	DF	-LogLike	RSquare (U)
110758	6	1085.2171	0.0075

Test	ChiSquare	Prob>ChiSq
Likelihood Ratio	2170.434	<.0001*
Pearson	2168.208	<.0001*

the largest discrepancies between observed and expected frequencies. Black students graduated at a much higher percentage rate from engineering technology program than engineering programs while Asian students demonstrated the opposite effect. The sum of all the cell chi-squares is an overall chi-square statistic for establishing that there are race difference between the two programs nationally.

In order to account for regional differences in race/ethnic population distribution, this analysis was applied to institutions by state. Appendix E contains the number and percentage of African American graduates of engineering and engineering technology programs by state. The IPEDS data revealed that in 40 out of 50 states Black students graduated at a higher percentage rate from 4-year engineering technology programs than from 4-year engineering programs. In those states where Africans Americans graduated at an equal or lower percentage rate from engineering technology programs than engineering programs, two states graduated no African Americans from any engineering related programs and seven states graduated less than 10 Black students from all engineering and engineering technology programs. One of these states does not even have engineering technology programs. The only state that graduated more than 10 African Americans from engineering related programs and had a higher percentage graduate from engineering programs than engineering technology programs was West Virginia.

Even within institutions that offer both engineering and engineering technology programs, the trend continues. Table 8 contains the breakdown by race/ethnic category by number of graduates and percentage of graduates from institutions that offer both engineering and engineering technology bachelor degree programs. Within the same

institutions, the ET programs have a higher percentage of Black graduates than engineering programs.

Table 8 Bachelor degrees granted in engineering and engineering technology programs from institutions that offer both degree programs: 2014

	Engineering		Engineering Technology		General Population***
	N	%	N	%	%
Black	1021	4.57	711	8.77	13.3
Asian	1621	7.26	347	4.28	5.6
Hispanic	1970	8.83	663	8.18	17.6
Other*	591	2.65	195	2.41	1.9
White (Non-Hispanic)	14369	64.38	5493	67.73	61.6
Non Resident Alien	1899	8.51	347	4.28	NA
Unknown	849	3.80	353	4.35	NA
* Native American, Hawaiian/Pacific Islander, and Two or More Ethnic Categories					
*** U.S. Census Bureau 2015 - https://www.census.gov/quickfacts/table/PST045215/00					

The chi-square test (Table 9) showed the same strong evidence of differences for Black graduates at institutions (N=128) that offered both engineering and engineering technology degrees. African Americans graduated at a higher expected rate from engineering technology programs and at a lower expected rate from engineering programs. Again, the sum of all the cell chi-squares is an overall chi-square statistic for establishing that there are race difference between the two programs even at the institutional level.

The data indicate that engineering technology degree programs provide African Americans with a more productive pathway (defined as earning a degree) into the field of

engineering. Engineering technology programs across regional boundaries graduate Black students at a higher percentage than engineering programs. Even within the same

Table 9 Race by ENG/ET programs for institutions which offer both degrees

		AS	B	H	NRA	O	UNK	W	Total
ENG	Count	1621	1021	1970	1899	591	849	14369	22320
	Row %	7.26	4.57	8.83	8.51	2.65	3.80	64.38	
	Expected	1443.55	1270.44	1931.3	1647.47	576.5	881.68	14569	
	Cell Chi^2	21.81	48.9757	0.7741	38.40	0.362	1.21	2.74	
ET	Count	347	711	663	347	195	353	5493	8109
	Row %	4.28	8.77	8.18	4.28	2.40	4.35	67.74	
	Expected	524.451	461.559	701.66	598.53	209.46	320.32	5293.0	
	Cell Chi^2	60.04	134.80	2.13	105.70	0.99	3.33	7.55	
Total		1968	1732	2633	2246	786	1202	19862	30429

N DF -LogLike RSquare (U)

30429 6 218.79573 0.0058

Test ChiSquare Prob>ChiSq

Likelihood Ratio 437.591 <.0001*

Pearson 428.861 <.0001*

institution, engineering technology programs graduate Black students at a higher percentage than the engineering programs. When graduates from HBCUs are removed, the percentages of African American graduates from both engineering and engineering technology degree programs do decrease but maintain the similar significant difference found in the other analyses. In the next section, the study begins to examine possible differences between engineering and engineering technology that helps in understanding reasons why African Americans find a more productive pathway into the field of engineering through engineering technology.

4.2 Curriculum Requirements

All engineering and engineering technology programs in four states²⁴ were examined to determine the degree requirements specified by the institution. Analysis of the degree requirements indicate that 1) all engineering programs require more and higher levels of mathematic courses than engineering technology, 2) engineering programs are more consistent with their scientific curriculum requirements than engineering technology, 3) engineering technology requirements for required mathematics and science courses vary to a greater extent from institution to institution, 4) engineering technology demonstrates a more “hands on” pedagogy, and 5) though engineering and engineering technology programs require similar engineering content courses, differences exist between engineering technology programs as to the level of mathematical expectation from which a course is taught.

The primary curricular differentiation between engineering and engineering technology programs is the level of mathematical expectation required for the particular degree program. This expectation is expressed in the number of mathematic courses required, in the level of mathematical courses required, and whether a particular engineering content course is taught from an algebra or calculus knowledge expectation. Largely due to the criteria for accreditation determined by ABET, all engineering programs surveyed (N=53) required Calculus III and Differential Equations (these numbers include institutions that required a combined differential equations and linear algebra course). Forty-three percent of the institutions required a linear algebra course in addition to the

²⁴ States surveyed include Georgia, Indiana, New Jersey, and Texas.

differential equations course. Thirty-two percent required an additional mathematics course (usually statistics) in addition these other courses mentioned. The engineering technology programs (N=32) contained more discrepancy in their mathematical requirements. Table 10 contains a matrix of the mathematical and scientific requirements of the engineering technology programs in the four state sample. The survey used the Electrical Engineering Technology degree as the curriculum surveyed. In the case of Texas, three institutions only offered a degree in Industrial Technology. Those three

Table 10 Math and science requirements of engineering technology programs in four states

	PreCal	Cal I	Cal II	Tech Cal II	Additional Math	Diff Eq	Phys I	Phys II	Chem I
GA (N=4)		0	3	0	0	1	3	3	4
IN (N=9)		3	2	5	3	0	6	3	4
NJ (N=2)		0	2	0	1	1	2	2	0
TX (N=17)	3	4	8	2	5	0	15	11	13
Information obtained from institutional online catalogues. N=Institutions. The cell numbers represent the number of institutions which require this course. At a minimum, all ABET accredited engineering programs require Calculus III and Differential Equations.									

programs only require Pre-calculus or any math courses as a requirement for the degree. In contrast to ABET accredited engineering programs which require at the minimum Calculus III and Differential Equations, engineering technology programs have not standardized their expected requirements in mathematics. As indicated by the national study on engineering technology by the National Academy of Engineering (NAE), the

program offerings within engineering technology vary greatly based on title, field, and focus (NAE 2017:8, 51-57). These variations have contributed to the perceived unequal quality across engineering technology programs.

Several of the institutions (N=7) had specific calculus courses for the technology programs. These courses were different from the regular calculus course offered. These courses were referred to as Calculus for Technology or Technical Calculus. The researcher phoned the institutions that offered such courses and asked how these courses differed from the other calculus courses. The clear theme in the responses was that these calculus courses were taught from a more applied mathematical perspective. Engineering content courses offered in the engineering programs are based on an expectation of a working knowledge of calculus. A phone survey of engineering technology college deans or department chairs found that this expectation varies not only by institution or program but also even by particular courses within the same program curriculum. Another issue that emerged from these phone conversations was the use of embedded mathematics. As indicated, most engineering technology programs do not require differential equations, however, many instructors embedded the necessary mathematics within the course instruction (such as control systems) so students can better understand the engineering concepts.

4.3 Requirements to take The Principles and Practice of Engineering Exam

The PE license offers several advantages to an engineer but the primary one is that “only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private

clients.”²⁵ The large majority of engineers who seek professional licensure are civil engineers. Pass rates from the October 2016 administration of the exam indicated that 59% of the exam takers were in the field of civil engineering as opposed to 12% from electrical engineering and 15% from mechanical engineering.²⁶

States are granted authority to oversee the licensing of engineers. The Society of Professional Engineers indicates that each “state has a different method of weighing unapproved engineering study, four-year engineering technology programs, four-year study in a science related to engineering, graduate study in engineering, the teaching of engineering, and engineering experience.”²⁷ Only 22 states (Appendix F) allow a graduate with an engineering technology ABET-accredited bachelor’s degree to sit for the PE exam.²⁸ All states require a number of years of work related experience as a criteria for taking the PE Exam. Engineering technology graduates, however, must demonstrate between 5-8 years of work related experience whereas the standard rate for graduates with engineering ABET-accredited bachelor degree is 4 years of work related experience. Many of the states do allow a caveat where educational credentials can be examined against a standard engineering degree offering to see if the courses and program structure are acceptable.

²⁵ <https://www.nspe.org/resources/licensure/why-get-licensed/advantages-licensure>

²⁶ <http://ncees.org/engineering/pe/>

²⁷ <https://www.nspe.org/resources/licensure/resources/faq#other%20ways%20to%20qualify>

²⁸ This information was retrieved from each states professional licensing website. Two states (WI and NC) allow graduates of two-year ET programs to take the exam after considerable years of experience.

CHAPTER 5. RESULTS OF SURVEYS AND SEMI-STRUCTURED INTERVIEWS

To better understand the role of engineering technology in the field of engineering and the role that engineering technology plays in attracting African Americans to the field, the study surveyed and interviewed engineering technology faculty and alumni/ae from two institutions in the United States. The survey questions can be disaggregated into three distinct areas: demographic questions, curriculum/program comparison with engineering, and workforce comparison with engineering. Both the curriculum and workforce questions were the same for both the faculty and alumni/ae surveys. The curriculum/program questions compared the curriculum topics and academic rigor between engineering and engineering technology programs. The workforce comparison questions focused on the employment opportunities for graduates with engineering technology degrees in the field of engineering. The demographic questions were different for the two surveys. The demographic questions on the faculty survey recorded current institution, professorial rank, tenure status, years as faculty member, race, and gender while the questions for the alumni/ae survey recorded institution from where they received their ET degree, age, race, and gender.

5.1 Faculty Survey

The results of the faculty survey are categorized based on responses to questions of curriculum comparison (CURR), academic rigor (RIGOR), workforce jobs (JOB), workforce placement (ENG), and attitude toward the Engineering Technology Council's

slogan “The degree is engineering technology, the career is engineering” (ETC). These responses were analyzed against the demographic factors of current institution (INST), professorial rank (RANK), whether or not the faculty member had obtained tenure (TENURE), years as a faculty member (YEARS), faculty member’s race (RACE), and faculty member’s gender (GND) using the Pearson Chi Square test. Table 11 contains the Pearson Chi Square and significance levels for each test (alpha level set at .05). Only one statistically significant difference is indicated: (RIGORxINST).

Table 11 Faculty survey - Pearson Chi-Square and Significance Levels

	CURR	RIGOR	JOBS	ENG	ETC
INST	3.31 .34	6.60 .03	6.24 .10	0.26 .60	0.88 .34
RANK	6.46 .37	3.77 .43	10.63 .10	.37 .83	.58 .74
TENURE	1.82 .60	.51 .75	7.47 .05	.00 .96	1.53 .21
YEARS	8.77 .72	6.97 .53	16.56 .16	1.99 .73	3.26 .51
RACE	16.63 .06	8.17 .22	10.10 .34	1.62 .65	4.29 .23

In regards to curriculum requirements, 59% of the faculty stated their ET programs were different or very different from engineering programs while 38% found the programs to be similar or very similar. The primary reasons for differences between the programs, based on faculty corresponding comments, were the level of sciences and mathematics and pedagogical format of particular engineering courses. A faculty member commented, “ET is lacking in science, mathematics, and other disciplines” and in engineering technology “some ET courses are trig-based versus calculus based.” Other faculty commented on the

theoretical perspective of engineering courses versus the hands-on, applied, laboratory courses of ET. One faculty wrote, “Engineering technology tends to target students who are more interested in applications and less interested in theory.” Another faculty commented that “the primary distinguishing factor curriculum-wise is an emphasis on hands-on experience in engineering technology programs, which means a significant part of the curriculum incorporates lab-based exercises.”

In regards to curriculum rigor, 56% found the engineering programs to be more rigorous than the ET programs, 31% found the programs to contain the same academic rigor, and 13% found the ET programs to be more rigorous. Those faculty who stated that engineering programs were more rigorous based their conclusion on the idea that engineering programs require more advanced mathematics making reference to engineering programs requiring at least one or two more advanced math courses such as differential equations than engineering technology programs. Engineering courses are taught from a calculus perspective while many ET courses are taught from either an algebraic, trig, or calculus perspective. One faculty from Purdue admits that engineering requires more advanced mathematics but questions whether or not such rigor is required in most engineering jobs, “Engineering is more academically rigorous in terms of the mathematical and theoretical context, requiring more out of class time than engineering technology. I don't, however, think that all jobs in engineering/technology necessarily benefit from the additional time/rigor.” One faculty member from Purdue, however, discussed the difficulty of determining what was rigorous,

This is difficult to answer as "academic rigor" is not defined. Engineers tend to use formulas and proof to define rigor to distance themselves from business, for example. But then talk about "rigorous case studies" when

borrowing from the business school curriculum. Others define rigor in terms of relevance and extending students' ability to think and synthesize new knowledge or insights. By the typical engineering definition, the courses in engineering technology are less rigorous. By the typical engineering technologist's view, engineering focuses on problems with less relevance to the world. (In engineering grad school, we often referred to the prototypical statement, "Assume a spherical chicken" to highlight lack of relevance.)

The Pearson Chi Square test indicated a statistically significant difference ($p < .01$) between faculty from Purdue and SPSU over the issue of academic rigor in programs. As possible explanation is that the Purdue engineering technology programs required students to complete mathematic courses up to the Calculus II level, while the SPSU engineering technology programs required students to complete both Calculus III and Differential Equations. As far as mathematics were concerned, the SPSU engineering technology curriculum was equal to most engineering degrees on the requirement of mathematics, therefore, the rigor normally associated with the mathematical elements of an engineering degree were the same for the SPSU students.

Though the engineering technology faculty see differences between engineering and engineering technology curriculum requirements, rigor, and preparation, they do believe that both degree programs produce a similar result: a career as an engineer. The engineering technology faculty were in agreement that graduates of engineering technology programs pursue similar jobs to those graduates with engineering degrees (90%) and that engineering technology graduates are hired as engineers as opposed to engineering technologists (91%) This belief is verified by two data points from the alumni/ae survey and alumni/ae interviews. Of the 634 alumni/ae surveys received, 461 indicated their current position title was as an engineer. Eight-two respondents indicated

that they no longer worked in the engineering field and 91 respondents did not provide a response. Only two titles provided included a position description of engineering technology or technician. Of the 21 interviewees, all held positions of engineers. The study has no means of verifying the actual titles of the respondents and must rely on the responses given. It seems reasonable to assume that they would support the ETC new tagline. The ETC, a formal entity within the ASEE, unveiled a new tag line in 2013: The degree is engineering technology, the career is engineering. The large majority of the engineering technology faculty in the survey agreed with this statement (88%).

When faculty were asked what the future of engineering technology was in the United States, over 70% were positive about the future of engineering technology, 15% were neutral, and 15% were negative. Those faculty that were negative about the future of engineering technology expressed concern that engineering technology programs would be discontinued or merged with engineering programs. The positive statements about the future of engineering technology focused on the applied nature of engineering technology and its ability to attract underrepresented minorities. Faculty expressed concern that engineering education has been unable to “break the historical 5% barrier of the BS-seeking student population” and believe that more emphasis on engineering technology could increase student enrollment, especially among underrepresented minorities. Another faculty member noted that engineering technology appears to be more attractive to minority students than engineering through his observations of students who attend the School of Engineering and the School of Engineering Technology at Purdue. The majority of the faculty responses concerning the future of engineering technology focused on the applied nature of engineering technology questions. Faculty believe that “engineering technology

will continue to fill the void between engineering science and the needs of industry” as employers demonstrate an “increasing desire to hire graduates with practical skills that can be readily applied to the workplace.” Clearly the faculty hope that engineering technology would be recognized in a more formal way as “applied engineering,” echoing back to Grinter’s (1955) suggestion that American engineering have both a scientific/mathematical track and a practical, applied track.

5.2 Alumni/ae Survey

The results of the alumni/ae survey are categorized based on responses to questions of curriculum comparison (CURR), academic rigor (RIGOR), workforce jobs (JOB), workforce placement (ENG), and attitude toward the Engineering Technology Council’s slogan “The degree is engineering technology, the career is engineering” (ETC). Using the demographic factors of undergraduate institution (INST), graduation year (GYEAR), race (RACE), and gender (GND), the Pearson Chi Square test was used for the statistical analysis. Table 12 contains the Pearson Chi Square and significance levels for each test (alpha level set at .05).

Table 12 - Alumni/ae survey - Pearson Chi-Squares and Significance Levels

	CURR	RIGOR	JOBS	ENG	ETC	
INST	29.34 .001	6.70 .01	5.97 .20	.40 .81	3.79 .08	
GYEAR	38.11 .001	37.43 .001	30.49 .01	51.68 .001	12.09 .01	
RACE	7.11 .13	22.85 .001	9.43 .05	7.47 .06	5.37 .07	
GND	2.85 .58	.89 .21	.44 .43	.54 .76	.25 .61	

5.2.1 Curriculum

In regards to curriculum requirements, 54.59% of alumni/ae stated their ET programs were similar or very similar to engineering programs while 27.04% found the programs to be different or very different. This result is opposite of the faculty's responses to the same question, resulting in a statistically significant Pearson Chi Square (17.56 $p > .001$). Southern Polytechnic graduates rated the curriculums more similar because the SPSU engineering technology programs required calculus III and differential equations. This difference in the math requirements between Purdue and SPSU was borne out in the significant Pearson Chi Square which showed that SPSU alumni/ae rated engineering technology program more similar to engineering than Purdue graduates (29.34 $p > .001$). The other significant chi square for curriculum was graduation year. This significant difference will be discussed in a separate section on graduation year since all of the chi squares for this variable proved to be significant.

Even though the alumni/ae and faculty disagreed on the similarities/difference of curriculum requirements, they did agree on the primary reasons for differences between the programs: level of sciences and mathematics required and pedagogical format. Alumni/ae from Purdue recognized that engineering programs at their institution required more advanced mathematics than engineering technology. An alumnus from Purdue wrote, "The Engineering program requires a much higher understanding of mathematics and the hard sciences than the engineering technology program. The engineering technology program lends itself to training in practical applications of technology." Another alumnus from Purdue was very straightforward, "Engineering programs emphasized mathematical theoretical aspects; engineering technology programs

emphasized practical laboratory aspects.” An alumnus from Purdue elaborated on his experience,

The engineering program was based on memorization of the curriculum and advanced mathematics, such as calculus. The engineering technology programs in 1982 were open book testing while most of the calculation based on addition, subtraction, multiplication, and division operations. The mathematics utilized really isn't much different, however, the approximation of the results and answers may have an effect on the accuracy and precision of the answers. The engineering programs were more theory, based while the engineering technology curriculum was more applications and hands-on oriented.

One alumnus from SPSU stated, “The engineering technology programs were more "hands on" and lab based while the straight engineering courses were more in-depth with theory.”

No matter whether the respondent thought the programs were different or similar, there was a clear bifurcation between curriculum pedagogy. Most of the responses included the terms “hands-on” or “applied.” Many of the responses indicated that engineering technology was more appropriate for the workplace and the practical application of engineering principals while engineering concentrated on the theoretical application and research. As one Purdue alumnus stated there is a “more of a real world feel to engineering technology.”

Many of the responses emphasized the importance of lab work in the engineering technology programs while the engineering programs were lecture based and focused on theory. One Purdue alumnus comments, “Engineering had about a year more math and was mostly theory while technology had a lab attached to every course in the major and provided much more hands on practical experience.” The respondents indicated that the

lab work was extremely important because it was in the labs that the educational transfer from theory to application occurred. A SPSU Alumnus states, “Engineering technology used the same text books as engineering and basically covered the same curriculum. The only difference was that engineering technology spent more time in labs doing hands on work.” Several of alumni/ae offered examples from their own educational experiences that reinforced the difference in pedagogy between engineering technology and engineering. A Purdue alumnus stated it bluntly, “I was in mechanical engineering for 2.5 years and I was a B student, however I was disappointed with the never-ending analysis and proof work. Mechanical engineering technology offered more hands-on labs, and most classes didn't go as deep into theory and proof but instead accepted the established principles as fact and went right into application (do we really need to show how to arrive at $F=MA$?)”. An alumnus from SPSU indicated that his studies at Georgia Tech were mostly lecture-based with the exception of one or two labs. His studies at SPSU incorporated lectures plus lab time. He commented that his classes at Georgia Tech were taught by “career professors or grad students, as opposed to industry professionals at SPSU.”

5.2.2 *Rigor*

In regards to curriculum rigor, the alumni/ae were divided with 50.72% responding that the engineering programs were more rigorous, 43.75% responding that the programs' rigor was similar, and 5.53% responding that the engineering technology program was more rigorous. Institution, graduation year, and race were indicated has having statistically significant difference on the variable of rigor. Graduation year is discussed in a separate section. As stated earlier, the SPSU alumni/ae rated the programs as similar in rigor because their program include Calculus III and Differential Equations. The Purdue

alumni/ae rated the engineering program as more rigorous because they were only required to take Calculus II. The African Americans alumni/ae who commented (80%) place a high value on the hands-on pedagogy of engineering technology as a sign of rigor. One SPSU African American respondent commented, that academic rigor was “only in the paper side of education. Technology provides more education to real world development and able to start without further instruction, where engineering can put someone behind a computer to solve design easier out the door without further education.” No statistically significant difference was shown between the faculty and alumni/ae on rigor.

Many of these respondents were quick to point out that they believed the ET programs were quite rigorous based on the emphasis on applied knowledge and its relationship to real world experience. A Purdue alumnus summarized this sentiment,

Purdue's engineering focus more on theory - in deeper aspects such as more required knowledge of math/ physics/ chemistry. But at the time I attended Purdue's electrical engineering technology lab work often had challenges to complete the lab work in the time give. This was especially true in the EET microprocessor classes which had no or limited "open lab" times to perform extra work to prepare coding and which at that time did not have any way for those few who had access to PCs to prepare ahead of time for the lab work and transfer the program via floppy disks or modems.

A SPSU alumni/ae pointed out the differences that institutional size and organizational structure make in evaluating and measuring rigor,

Georgia Tech had an antagonistic and competitive academic atmosphere, especially with the large lecture-hall sized classes. All of SPSU's classes were small (20-50 students) so the academics seemed easier due to closer contact and interaction with professors...SPSU professors actually knew you and invested time in your academic achievements (similar to recitation classes at Georgia Tech).

5.2.3 *Jobs as Engineers.*

A large majority of alumni/ae indicated that graduates of engineering technology programs enter the engineering workforce as engineers (87.0%). Of the 634 alumni/ae surveys received, 461 (72%) indicated their current position title was as an engineer. Eight-two respondents indicated that they no longer worked in the engineering field and 91 respondents did not provide a response. Only two titles provided included a position description of engineering technology or technician. Of the 21 interviewees, all held positions of engineers. The study has no means of verifying the actual titles of the respondents and must rely on the responses given. No statistically significant difference were found between the alumni/ae (other than graduation year) nor between the faculty and alumni/ae responses. Many indicated that this conclusion was based on personal experience, experience in hiring at companies, and interaction with engineering colleagues during their careers. Six respondents wrote that they had never even encountered the position of engineering technologist in their careers.

Only a small percentage of alumni/ae believed that graduates from engineering technology programs were hired as engineering technologists (8.96%) or engineering technicians (4.04%). No statistically significant difference were found between the alumni/ae (other than graduation year) and the faculty and alumni/ae responses. Several respondents indicated they had experiences graduates being hired into all three of these positions as reflected in this quote from a Purdue alumnus,

In my experience, it is all of the above and depends on the individual. We have several electrical engineering technology graduates working for us. All are four year degree graduates. Some are technicians, some staff engineers. One engineering technology graduate is our engineering manager. The VP

and Owner of the company graduated with an engineering technology degree. We have Electrical Engineering graduates in engineering positions but not as technicians.

Other respondents predicated their response based on the institution from which a graduate received their degree. These respondents were attuned to the differences that exist between engineering technology programs across the nation. A Purdue alumnus commented, “Again it depends on the company, and on the engineering technology program. Devry and IVY Tech technology students have typically been technicians. Purdue Technology and Texas A&M graduates have engineer titles.” Others predicated their response based on whether or not the graduate had completed the PE exam or the Foundations of Engineering (FE) exam. A SPSU alumnus stated, “I have seen where they have been hired as both engineers and engineer technicians. Most are hired as engineering technicians or engineering technologists unless they have passed the Fundamentals of Engineering exam.” The large group of the respondents confirmed that though the academic world makes a clear distinction between an engineering degree and an engineering technology degree, industry does not care or as a Purdue alumnus stated “most employers do not know the difference.” One SPSU alumnus commented,

The colleges, institutions, and governments (Federal, State, Local) make the distinctions among graduates. Industry tends not to make the distinctions. Industry is looking for somebody to perform the work. I was hired by Westinghouse Electric Corporation upon graduation from the Southern College of Technology. The recruiter who interviewed me told me that the industry preferred technology graduates because of their extensive exposure to engineering application.

Finally, several respondents discussed the discrimination against engineering technology graduates. Discrimination takes the form of unequal job titles, restrictive state law on PE examinations, prejudice by individuals with engineering degrees, and some companies and governmental agencies who will not hire graduates with engineering technology degrees. A Purdue alumnus noted that his company would hire graduates of engineering technology programs as engineering technologists and not an electrical engineering title. This practice was consistent even if the engineering technology graduate had obtained the professional engineering license. Another Purdue alumnus commented specifically about his career experience at the Caterpillar Corporation. He was hired as an engineer and, at that time, there was no distinction between the titles for those with an engineering degree and engineering technology degree. At some point, however, Caterpillar changed that policy and now labels those with engineering technology degrees as technologists. He states that there is no difference in the work requirements but if a job is posted strictly as an "engineering" job title, the applicant must have an engineering degree. A black alumnus from SPSU wrote that after graduation, he had a difficult time finding a job as an engineer. Ultimately, he was hired by a major engineering corporation as technician. He has consistently attempted to change his role to an engineering job, but in his experience "most employers don't see that engineering technology equals engineering."

5.2.4 Engineering Technology Council Slogan

When asked if they agreed or disagreed with the ETC slogan that "the degree is engineering technology, the career is engineering" the large majority (93.8%) stated that they agree with the statement and only 6.2% disagreed with the statement. No statistically

significant difference were found between the alumni/ae and the faculty and alumni/ae responses. Those who choose to expand on this statement most pointed out that as a career “engineering is too broad of a title to be associated or disassociated with a degree” and that the field required both the expertise provided by graduates from both engineering and engineering technology. A Purdue alumnus commented, “Engineering fields and engineering technology fields overlap to such an extent that anyone thoroughly trained in either field can perform the work required in the other.”

Some respondents described the relationships between engineering technology and engineering as a dual track metaphor where engineering deals with research and design while engineering technology focus more on industrial application. An alumnus from SPSU states, “The engineering technology degree lends itself to immediate employment in a manufacturing or hands-on environment. In contrast, the engineering degree appears to be better adapted to engineering research type careers.” In almost all responses there is a deep appreciation for the applied nature of engineering technology. The respondents replay stories of how the applied pedagogical nature of the engineering technology education provided them with an understanding of engineering in the real world. A SPSU alumnus writes, “As mentioned above, all technology students are well prepared for engineering careers. In fact, because of the applied nature of the degree, I would say most are better prepared to start their engineering career than someone who has an engineering degree.” A male respondent from Purdue mentioned work experiences where “my friends who were in the engineering school would often come to me with questions when they were tasked with a real world project.” One alumnus from Purdue suggests that the U.S. model the European labeling of engineering technology,

In Europe, engineering technology courses are called Applied Engineering. That is what my major should be called, as we study and reproduce theory based teaching with lab work, and in the lab we take it a step further. I can't believe the two programs are still separate. It's time to combine them. It is all engineering. I would rather have the technology degree be called applied engineering. That's what is it.

Those respondents that disagreed with the slogan did so because they have experience continued discrimination against those with engineering technology degrees. This discrimination follows the same patterns recorded in previous responses including unequal job titles, restrictive state law on PE examinations, prejudicial attitudes from individuals with engineering degrees, and some companies and governmental agencies who will not hire graduates with engineering technology degrees. The following are representative examples of these sentiments:

Typically the technology graduate is not respected unless they obtain their P.E. But many states follow a movement among "purists" in the engineering curricula, and graduates of engineering curricula, to disallow "engineering technologist" from sitting for the EIT and Professional Practice examinations. – Purdue alumnus

When I was first hired, my company allowed those with either degree to fill engineering positions, but now they only allow those with a degree in engineering. – SPSU alumnus

Engineering seems to be a little different than engineering technology in most companies and typically carries a little more "prestige" than engineering technology. – Purdue alumnus

There is a stigma associated with "technology" branded degrees. However, once employers see the skill sets of 4 year technology graduates they are hired as full engineers or project leaders. – Purdue alumnus

5.2.5 *The Future of Engineering Technology*

Respondents were asked “What is the future of engineering technology?” A smaller minority (22%) believed that engineering technology was obsolete, would merge with engineering, or would remain subordinate to engineering. The majority (78%) of the respondents were positive about engineering technology’s future but qualified that positivity with certain criteria such as creation of dual tracks within the field of engineering or the need to focus on applied fields. A primary theme which emerged from the respondents’ comments echoed a concern that engineering technology’s inability to distinguish itself from engineering was a major hindrance to its development.

Those respondents who were not positive about the future of engineering technology (22%) predicted that its direction would move along two trajectories: cease to exist, remain subordinate to engineering, or merge with engineering. Those respondents (4%) who believed that engineering technology programs would cease to exist based their predictions on the regulating of PE licensing boards and the expansion of engineering programs. A Purdue alumnus wrote, “Somewhat bleak. Many states are moving toward refusing professional licensing to engineers holding engineering technology degrees.” A SPSU alumnus provides a real world illustration of this trend, “In Georgia, it is going away. Since the state now has more engineering programs (besides just GA Tech), the ET programs enrollment is lacking. Why would you go with an ET degree and have to wait an additional 3 years for a PE if the same school you would be going to offers engineering.” The real world example refers to the addition of engineering programs at SPSU and Georgia Southern University who once offered only engineering technology. This

expansion also includes the addition of mainstream engineering programs (mechanical, electrical, civil) at the University of Georgia.

Another reason for a negative perspective on engineering technology's future was the inferior status they felt engineering technology had within the field of engineering (12%). Most did not believe that engineering technology could escape this inferior status. One SPSU alumnus stated bluntly, "I wouldn't pursue the technology option if I had the option for a do over. The technology label and perception that it was a lesser degree than a traditional engineering program limited my opportunities throughout my career, irrespective of actual performance." This study has commented on the issue of status in the field of engineering. Clearly, many respondents had experienced the superior status of those with an engineering degree who "think of themselves as superior and engineering technology is an inferior career field that is a threat to engineering supremacy" (Purdue alumnus).

The last negative group (6%) believed that the current trajectory of the two programs as well as increases in modeling technology was blurring the lines between the two programs. This blurring of the lines would lead to the merge of engineering technology with engineering. A Purdue alumnus predicted that engineering technology programs would "morph to be same as engineering. At that point, they will merge and consolidate due to the educational overhead."

Those respondents who had a positive outlook on the future of engineering technology (78%) saw that future unfolding along different trajectories. A large subset of the positive group (31%) saw the blurring of lines between the two programs as detrimental

to engineering technology. These respondents believe that a clear distinction between the two programs would not only benefit engineering technology but the overall field of engineering. This need for distinction between engineering and engineering technology disciplines has been tried many times by proponents of engineering technology. These respondents were well aware that an attempt at distinction has been tried before without success. Their solution to the issue of distinction is the addition of an important requirement: equality. The programs should operate as two options within the field of engineering; one being more scientific and theoretical and one being more applied and hands-on, but they should be seen as two equal tracks within engineering. A Purdue alumnus writes, “The direct application during school that technology has allows technology graduates to join in faster and have a far more practical perspective of the subject matter than a purely engineering graduate.” It is the elevation of engineering technology to the level of applied engineering that would create the equality that most within engineering technology believe must occur for engineering technology to survive as an academic program. Such an elevation would address the racial issue of the dominant group’s use of valuing theoretical knowledge and learning by placing applied knowledge and pedagogy on the same level as scientific knowledge and theoretical pedagogy.

The largest subset (47%) were positive about the future of engineering because they recognize industry’s need for applied engineering and real world knowledge. Many pointed out that as engineering became more of a science during the 1970s, its applied nature dissipated. Governmental funding became of the focus of engineering programs and the needs of industry were neglected. These respondents now see a resurgence in the industry’s role in the engineering education arena. An alumnus from Purdue believes, “The

future is bright. Engineering technology degrees better prepare the student for the workforce. Engineering degree students have a larger learning curve to adapt to corporate culture from the academic culture they learn.” This group again raises the applied nature of the engineering technology program as being a significant factor in the success of the degree and its degree holders. Industry always needs engineers who know how to apply their engineering theory, “My employers have recognized my ability to not only design work based on engineering theory but also perform the field work with my hands on experience and it has really helped me in my career!”

5.2.6. Graduation Year Significance

The graduation year variable showed statistically significance differences across all of the dependent variables (see Table 12). The contingency tables show no clear trends other than more recent graduates of engineering technology were more optimistic about engineering technology versus engineering. A possible explanation could be that “Hired as Engineer” variable indicated that those graduates from the 1960s and 1970s were not always hired as engineers but as engineering technicians while hardly any respondent from the 2000s indicated that engineering technology graduates are hired as engineers.

5.3 Alumni/ae Interviews

This section will be organized by the four questions on the survey: 1) Why did you choose engineering technology as a degree program instead of engineering with a follow-up question of whether the interviewee felt adequately prepared for the program’s mathematical requirements, 2) While you were at your institution, did you observe any form of discrimination against minority students, 3) Did you face any challenges in your

career because you had an engineering technology degree as opposed to an engineering degree, 4) Minority students appear to gravitate toward engineering technology as opposed to engineering. Why do you think engineering technology is more appealing to minority students than engineering?

5.3.1 Choosing Engineering Technology over Engineering

The responses from the interviewees (N=21) on why they choose an engineering technology degree program over an engineering program affirmed the primary responses received from the survey.²⁹ The top reason for choosing engineering technology (N=16) was that these programs were offered during the evening hours and were accessible to those who worked. Six of the eight African-Americans interviewees indicated that work flexibility was one of the reasons they choose engineering technology, while ten of the thirteen Caucasians interviewees listed this as a reason. Another reason that was evenly divided between African-American (N=7) and Caucasian interviews (N=7) for choosing engineering technology over engineering was cost. The engineering technology programs cost less than the engineering programs. Another top reason for Caucasians interviewees (N=9) for choosing engineering technology was the hands-on learning pedagogy, “so I like the ability to have labs and they were promoting real world experiences with the work we were doing . . . I’m less of a theory type of learner, more of a hands-on type.” Four of the eight African-American interviewees also indicated that the hands-on learning pedagogy was a reason for them to choose engineering technology.

²⁹ Of the 21 interviewees, 17 of them gave multiple reasons for choosing engineering technology.

The follow-up question concerning their mathematical preparation produced little information. Most of the interviewees indicated that they felt adequately prepared for the math courses they took during their degree programs. One African-American alumnus from SPSU did indicate that he had come from a high school “in rural south Georgia, so we didn't have calculus. The biggest exposure I got was pre-calculus.” The interviewee enrolled in a challenge program at Georgia Tech where he took 4 to 5 quarters of calculus. He then transferred to SPSU and switched from engineering to engineering technology. At SPSU, he took differential equations. Another interviewee from Purdue indicated that he did not have enjoy math in high school and was concerned about the advanced math at Purdue. But his engineering technology calculus and differential equations courses were taught in conjunction with solving engineering problems, “after understanding and solving problems and seeing what the real world concept is and was with math at the time, then I had a better appreciation for it.”

5.3.2 Forms of discrimination against minority students

Only two of the 21 interviewees indicated that they had witnessed discrimination due to race at their institutions. One interviewee experienced discrimination from one or two teachers where he felt “ostracized at times due to my race.” The other interviewee did not experience discrimination personally but observed instance of discrimination against minority students that were “sometimes subtle and sometimes obvious.” Neither were willing to elaborate on the specifics of these experiences. One African-American interviewee from SPSU complimented the institution for their inclusion and diversity work, “At both schools (SPSU and Georgia Tech), I felt like there were very good minority affairs type of organizations.”

The lack of reported incidences of racial discrimination from the respondents is contrary to the other research on racial discrimination in engineering. Riley (2005) finds that the engineering mindset and predominance of white, male engineers in the United States creates an environment in which racial discrimination is not recognized by the dominant group. This racial discrimination manifests itself in the form of racial jokes, devaluing of non-white engineers, and requiring non-white engineers to prove themselves. Hoke (2013) relays a similar circumstance where a black engineer is subjected to racial jokes and work devaluation. This racial discrimination translates into less pay, delayed or prolonged promotion, and a disincentive toward management (King 2003; Shenhav 1992; Tang 1993). Research on workplace discrimination in engineering is lacking but research in similar discrimination in the engineering academic setting abounds. Foor (2007) examines the intersectionality of race and gender by tracing the many experiences of racial discrimination of a female minority engineering student. These incidences of racial discrimination mirror those mentioned in the workplace experiences, racial jokes, devaluing of work, the requirement to prove oneself capable. Robinson (2016) specifically points to experiences of racial discrimination in engineering degree programs deterring Black and female students from pursuing academic careers in engineering. Other studies suggest that racial discrimination in engineering school impeded the success of black engineering students (McGee and Martin 2011; Charleston et al. 2014; Harpalani 2007).

5.3.3 Challenges of Engineering Technology degree

When asked if they faced any challenges in their careers because of having an engineering technology degree as opposed to an engineering degree, most of the interviewees indicated that they did not feel their careers were hampered by having an

engineering technology degree, especially while on the job. The only caveat these interviewees had was during the times of hiring and interviewing. During the application for a position or during the interview process, the issue of having an engineering technology degree surfaced. The interviewee would have to explain what an engineering technology entailed or indicate the work performed in previous positions. Several interviewees indicated that once they explained the hands-on experience learning that they received with their engineering technology degree, the employer actually preferred them. One interviewee stated, “The guys I worked with today, I’m in marketing now, and the guys I work with today in the shops and services, they favored the technology degree more than they do the engineering degree.”

Three interviewees stated that they had faced challenges in their careers due to the engineering technology degree. One interviewee observed that engineering technology graduates were assigned to field testing positions while graduates from engineering programs were assigned to development positions. One interviewee believed that his engineering technology hindered him early on in his career but as his career progressed the hindrance vanished. He stated, “But, hey, when I started at FedEx, you know, 20 years ago, it did look like it was going to be an issue for a minute there because they really did start trying to look and say, “Well, if you have an engineering technology degree, you can’t be an engineer.” As with most engineering technology graduates, this perception of the engineering technology degree vanished once that employer saw what ET graduates could do. An African-American from SPSU interviewee did not indicate that his engineering technology degree was a challenge during his career but did state that he saw the issue of “sponsorship” hinder many minority engineers.

Performance is part of it, but it's really about sponsorships. So you go to an interview, I just interviewed for a Director position. And, you know, I got the opportunity to talk to my Senior VP, you know, it boils down to, a lot of it boils down to who's going to call and vouch for you? So the person that's out here working, working hard as they can every day to do what they're supposed to do, if you hadn't reached out to other people and built a network of VPs and Senior VPs that'll call and say, "Hey, boss, so in so is a good candidate, he's done good work for me, you know, I think he'd be good for your Director position". If those things don't occur, then you don't have a chance. But a lot of people, minority, however you want to say it, don't have that opportunity and don't have that coaching because there's not a lot of minorities there to do the coaching.

5.3.4 Minority students and Engineering Technology

When asked why engineering technology is more appealing to minority students than engineering, many of the Caucasians interviewees felt inadequate to comment on this question. Those (N=4) who did provide responses listed three reasons why engineering technology would be more appealing to minority students: entry requirements, high school programs, and math preparation. The interviewee who listed entry requirements as a reason was from SPSU and was referencing the fact that Georgia Tech is more selective and has higher entry requirements than SPSU. The interviewee who listed high school programs was referencing programs such as Project Lead the Way³⁰ which he believed was offered more in urban schools and pushed high school students toward tech programs rather than engineering programs.

In contrast to the responses of the Caucasian interviewees, the African-American respondents listed the reasons why minority students gravitated toward engineering

³⁰ Please see the following URL for more information on Project Lead the Way: <https://www.pltw.org/our-programs/pltw-engineering>

technology as the same practical reasons for choosing engineering technology that most of the respondents listed during Question 1: Cost, Flexibility, and Hands-On Learning. Six of the eight African American respondents indicated they believed that most minority students would need to work while obtaining their degree and therefore would look for the less expensive options and the options that allowed them to work during the day and attend class in the evening, “I think that engineering technology schools tend to see themselves as needing to serve that after hour crowd.”

5.4 Summary

The data from the surveys and interviews coalesce into several reoccurring themes. These themes are the uniformity within the engineering technology constituents, the importance of hands-on pedagogy, the role of mathematics as a symbol of rigor, reasons for choosing engineering technology, engineering technology grads as engineers, and continuing barriers for engineering technology graduates. Chapter five concludes with summarizing these themes while Chapter six elaborates on them and their implications for African Americans in the field of engineering.

The constituents within the study’s engineering technology sample are uniform in their perceptions about the degree and how engineering technology operates in the field of engineering. Engineering technology faculties at Purdue and SPSU demonstrate only one statistically significant difference between them. The faculty members from these institutions did demonstrate a statistically significant difference on the issue of rigor within the curriculum with the Purdue faculty rating the engineering programs as more rigorous while the SPSU faculty rated the rigor within the two programs as more similar. As stated

previously, the Purdue engineering technology programs required students to complete mathematic courses up to the Calculus II level, while the SPSU engineering technology programs required students to complete both Calculus III and Differential Equations. This statistically significant difference provides a juxtaposition with another theme of mathematics as a symbol of rigor.

The two faculties did agree on the other issues surveyed. They agreed that the curricular differences between an engineering degree and an engineering technology degree were not found in the engineering topics required in the curriculum but in the level of mathematics and science courses required and the pedagogical approach (see sample faculty quotes from page 91). The faculties also agreed that engineering programs utilize a more theoretical pedagogy while engineering technology utilizes a more applied pedagogy. It is interesting that alumni/ae who were surveyed reached a similar conclusion on the differences between the degree programs but the majority of alumni/ae (54.59%) rated the curriculums as more similar or similar. A possible explanation is that faculty focused more on the actual curricular requirements while the alumni/ae focused more on the results of the degree programs which was being hired as an engineer.

The faculty members and alumni/ae were uniform in their belief that engineering technology graduates are hired as engineers and that engineering technology leads to a career in engineering. The faculty members and alumni/ae also were uniform in their belief that the future of engineering technology rested on the applied, hands-on nature of the engineering technology educational pedagogy. The alumni/ae demonstrated uniformity as a group as well. As mentioned above, the majority agreed that engineering technology graduates are hired as engineers. They agree with the statement that engineering

technology leads to a career in engineering. Many believe that the hands-on instruction they received in their education benefitted them in their work careers and provided a value added advantage over those with engineering degrees in the workplace.

Though the engineering technology faculty value and understand the importance of the applied, hands-on pedagogy of the engineering technology program, it is the alumnae/us who highly value and truly appreciate the role it played in their education and work careers. The data from both the alumni/ae survey and the interviews suggests that one of the primary reasons these individuals choose engineering technology was the applied, hands-on pedagogy of the program. The ability to understand complex engineering concepts in the form of real world problems was central to the success of these alumnae/us. The abundance of laboratories which accompanied the theory based lecture courses was proclaimed as a more effective educational pedagogy, whose results were realized not only in the educational setting but in the world of work. When arguing for the continued future of engineering technology, the applied, hands-on instruction is primary and critical component for engineering technology's continued existence and advancement according to the alumni/ae respondents. The study does acknowledge that socio-economic status also could be a factor in this finding and future research will need to determine the intersectionality between race and class on this issue.

Though the question to alumnae/i interviewees about having an adequate preparation in mathematics produced little results, the idea of mathematics as a symbol of rigor in engineering persists. Previous research (Staton 2010; Pearson & Miller 2012) specifically names mathematics as the primary determinant in pursuing, entering, and graduating with an engineering related degree. The surveyed faculty indicated that

engineering degrees are more rigorous because they require courses in higher levels of mathematics. The Purdue engineering technology alumnae/i attribute both curricular differences and increased rigor in the engineering programs at Purdue as compared to their engineering technology degree due directly to required advanced mathematic courses. The SPSU graduates were proud that their engineering technology degree program included Calculus III and Differential Equations as requirements. Because it remains a powerful symbol in engineering, the role of mathematics as an exclusionary device will be discussed in Chapter six.

The most significant data emerging from the alumnae/us interviews were the reasons for choosing an engineering technology program over an engineering program. The reasons indicated have nothing to do with a status/prestige hierarchy, a rigorous selectivity process to engineering programs, or the requirements of advanced mathematics. The reasons are related to accessibility where individuals are constrained to select an engineering related program that meshes with their work schedules and financial situation. These reasons, however, continue to be institutional structures/barriers within engineering programs which act as mechanisms of social closure, constrain choice, and create unequal access. Seventy-one percent of the interviewees indicated that they chose an engineering technology program because it provide flexibility that accommodated their work schedules. Seventy-five percent of the African American interviewees indicated that such flexibility was a reason for choosing an engineering technology program. Tuition and fees proved to be a primary reason for the alumnae/us of SPSU because their program as SPSU costs less than the engineering programs at Georgia Tech. The Purdue Alumnae/i faced less of a tuition and fee difference though it was factor for some Purdue alumni/ae.

Currently the Purdue engineering program does charge an additional \$2050.00 fee while the additional annual fee for engineering technology is \$572.00³¹.

As discussed in the section on the uniformity of engineering technology constituents, the majority of these constituents believe that engineering technology graduates are hired and work as engineers as opposed to engineering technologists or technicians. Yet even with this show of solidarity, barriers and obstacles for engineering technology graduates still exist. Those barriers and obstacles manifest themselves in the form of 1) a perceived inferiority of engineering technology to engineering, mostly from those with engineering degrees and 2) institutional structure discrimination. Because of its smaller number of programs in the US and its lack of advanced mathematic requirements, engineering technology is seen as an inferior version of engineering. A respondent from SPSU stated that his engineering colleagues refer to it as “engineering lite.” As this study has demonstrated, status and prestige are particular important dynamics in the field of engineering and therefore it is not surprising to discover a need to develop hierarchy within the culture of engineering. The data from the surveys and interviews corroborate the findings in Chapter four that institutional discrimination exist against engineering technology graduates when they attempt to become licensed professional engineering and apply for federal engineering positions.

³¹ See <https://www.admissions.purdue.edu/costsandfinaid/tuitionfees.php>

CHAPTER 6. CONCLUSIONS

African Americans are disproportionately underrepresented in the field of engineering within the United States. This underrepresentation by a significant population group jeopardizes the competitiveness of the United States in the global market in the arena of innovation and technological development. In his assessment of Ph.D. production, Fechter (1994) notes that policy issues address such production fail to incorporate the issue of underrepresented groups. These policy attempts do not address directly the barriers that prevent qualified individuals from these underrepresented groups (women and ethnic/racial groups) from pursuing a career in engineering or the sciences. He states, “Underrepresentation is an indicator of talent that is not exploited to its fullest potential” (1994:138). This study examines the role that engineering technology plays in addressing the disproportionate underrepresentation of African Americans in the field of engineering. IPEDS data presented in this study demonstrate that African Americans enroll and graduate from engineering technology programs at much higher percentage rate than from engineering programs. If the United States wants to increase the number of African Americans entering the field of engineering, then engineering technology provides a potential pathway into the engineering workforce, but currently an unequal one as compared to those with an engineering degree.

This pathway, though a viable means into the engineering workforce, does have its obstacles and its gatekeepers. Engineering technology exists as a second tier structure within the field of engineering, subordinate to engineering. Though graduates of engineering technology programs move into engineering positions in industry, the

transition into the field and then subsequent career moves sometimes are hindered by their degree. Mathematics has been determined to be a primary factor in determining an engineering career (Pearson & Miller 2014). Mathematics, however, is used as a gatekeeper in the selection and progression of engineering degree candidates. This selectivity results in individuals who have had poor mathematic preparation from seeking engineering degrees which disproportionately effects African Americans (NSB 2012; Denson 2010:71; Staton 2010; Malcom-Piqueuz 2013; Maton 2012). Other gatekeeping factors include costs of degree program and flexible scheduling of program courses. The study's research findings indicated that individuals choose engineering technology programs because they were less expensive and offered courses at flexible times for students who needed to work fulltime. These factors aggregate into a form of credentialism that results in African Americans funneling into engineering technology.

The study explores this role of engineering technology within the field of engineering and the possible effects on its graduates obtaining an engineering degree. This study explores two questions that seek to address the issue:

- 1) has the engineering field created a socially stratified structure that has limited its upper tier to select racial/ethnic groups?
- 2) does the knowledge and technical expertise of engineering technology act as a pathway to the field of engineering for African Americans?

The chapter proceeds by addressing each question individually and then collectively, connecting the discussion to previous research. The chapter then provides an application of the study's theoretical perspectives to the findings. The chapter concludes

with the limitations and contributions of the study, possible directions for future research, and potential public policy implications.

6.1 Discussion of Questions Posed

6.1.1 Engineering as a Racially Stratified Field

Daryl Chubin states the situation quite succinctly, “the US engineering workforce does not look like America” (2015:389). Clearly, the population of engineers in the United States is predominantly white and male. The literature review outlines both individual and institutional forms of racism within the field of engineering which are embedded into institutional structures, general cultural discrimination, and individually held stereotypes of African Americans. Racism toward African Americans in engineering manifests itself as attitudinal and/or behavioral discrimination and institutional racism. These racist manifestations are grounded in the historical development of engineering. The Tuskegee model created a trajectory of industrial education for blacks which propelled them to be technicians of engineering but not engineers. HBCUs emerged as a way to educate African Americans but also maintain a segregated educational system. The technologically related programs in most HBCUs began as 2 year degree programs to train technicians not engineers (Pierre 2015:14). Engineering programs at HBCUs flourished in response to federal mandates to educate black students in engineering because whites in the South wanted to preserve the racially segregated system (Pierre 2015:15). The Engineer’s Council for Professional Development (ECPD, later known as ABET) accredited only one

HBCU engineering program in 1960 at Howard University³². Not until the early 1970s with the persistence help of ASEE, the ECPD accredited six engineering programs at HBCU institutions. The National Society of Professional Engineers did not allow professional licensing/membership for Black engineers until the 1960s.

Institutional forms of racism found reviewed in the literature include the inadequate preparation for and exposure to mathematics and advanced science at the secondary educational level (NSB 2012; Smith 2003:62-63; Denson 2010:71; Pearson & Miller 2012), the lack of adequate lab and science facilities within secondary schools or advanced math and science courses due to low tax revenue districts in which they reside (Slaughter, Tao, and Pearson 2015; Reed 2001; Murray, Evans, & Schwab 1998; Kozol 1991), and the selectivity/rigor/weeding out process (Slaton 2010). Individual forms of racism or discrimination emerge largely from the engineering mindset and predominance of white, male engineers in the United States which creates an environment in which racial discrimination is not recognized by the dominant group (Riley 2005). This racial discrimination manifests itself in the form on racial jokes, devaluing of non-white engineers, and requiring non-white engineers to prove themselves.

This racial discrimination occurs in both the engineering academic setting and the engineering workplace (Robinson 2016; Foor 2007; King 2003; Tang 1993). Black engineering students are expected to not perform as well as white males in science and engineering (Dickey 1996). Students of color, especially women of color, are not recognized as legitimate members of the STEM community (Carlone & Johnson 2007).

³² This study wishes to note the lack of research on the historical relationship between the ECPD/ABET and racial discrimination.

African Americans in STEM have to perform at a much higher level to prove themselves by performing extra work to gain acceptance (Robinson 2016; McGhee & Martin 2011; Ong 2002:43) by professors who already hold, due to stereotypical attitudes, expectations that black students are expected to fail (Borous-Hammath 2000:109; Varma 2006; Carlone & Johnson 2007). Black students, therefore, develop personal and professional isolation while pursuing a STEM degree program due to stereotypical attitudes (Denson 2010; Justin-Johnson 2004; Brand, Glasson, & Green 2006). Numerous studies demonstrate that this isolation is enhanced for black students and the stereotypical attitudes in STEM is affirmed by the lack of role models and mentors of color (Leggon 1997; Maton 2012; Fleming 2008; Beasley 2012; Perna 2010; Ong 2012; Smith 2003). The personal and professional isolation creates an environment in which only the select few can “successfully navigate exclusion and their unique representation in science on their path toward becoming a scientist” (Hurtado 2009:193). These forms of individual and institutional racism make it difficult for African Americans to develop a technological identity while at the same time that they maintain their racial identity (Hurtado 2009:210).

The current study’s findings point more toward examples of institutional racism as opposed to individual discrimination against African Americans in the field of engineering. National data as well as the IPEDS data presented in the study clearly indicate the underrepresentation of African Americans in the field of engineering at both the educational and employment levels. The graduation rates from engineering programs indicate that the underrepresentation of African Americans in engineering programs occurs in every state across the U.S and is not isolated to a particular region of the country.

The study does find particular forms of institutional racism within educational engineering programs which provide substantive obstacles to African Americans pursuing an engineering degree and funnels African Americans into engineering technology programs. The study does recognize that these findings are limited because of the smaller number of participants interviewed and the limited number of institutions surveyed. From these small samples, these institutional structures of racism did affect the accessibility of engineering programs for these African Americans individuals and included the cost of programs, location of programs, and accommodation of programs to work flexibility. The study finds that the African American engineering technology graduates in the study's sample indicated that they chose an engineering technology program over engineering program due these accessibility constraints. Though the study does conclude that engineering technology is a potential pathway into engineering for the graduates of the programs surveyed, the study also concludes it is an unequal pathway. Engineering technology graduates are not allowed to apply for federal engineering positions. Engineering technology graduates cannot take the exam to become a professional licensed engineer in more than half of the states in the U.S. engineering technology is viewed as a second class degree program by engineering programs. And yet African Americans are funneled into engineering technology by the institutional structures mentioned above so that they graduate at a much higher percentage rate from these programs over engineering. Such an unequal system/structure could be deemed institutional racism.

In sum, the review of the literature and the current study suggests that mechanisms of control and social closure with the educational system of engineering creates a culture of inequality in the production of engineers. This culture of inequality for African

Americans in the educational system of engineering is created through inadequate preparation of black students at the secondary level, the resulting issues of academic selectivity, constraints on accessibility into engineering programs, unequal educational credentials for federal employment and licensing structures, and the creation of a viable but unequal pathway into the field. The previous research in underrepresented minorities in STEM fields highlights a number of these mechanisms of control and closure. Limited educational resources at the secondary level impeded black students in their mathematical and scientific intellectual development thus placing them at a disadvantage in being accepted into engineering programs and progressing through those programs. Mathematics and other engineering concepts taught through abstract pedagogies are not conducive to the learning styles of many African Americans. Black students face isolation within engineering programs due to the lack of peers or role models within the programs. Because of their token levels, many underrepresented minorities face blatant discrimination. Engineering's desire to remain a high status academic discipline and profession creates barriers/mechanism of control and closure, such as selectivity, rigor, and a sink or swim attitude, which impeded the entry and success of underrepresented minorities. The current study highlights the constraints on accessibility which funnels many African Americans into engineering technology programs. The current study also concludes that engineering technology is a viable pathway into the field of engineering, it is also an unequal pathway.

6.1.2 Engineering Technology as Potential Pathway in Engineering

The study determined that engineering technology graduates a higher percentage of African Americans than does engineering. IPEDS data clearly support the idea that engineering technology acts as a potential pathway for African Americans into the

engineering workforce. The overall percentage of African Americans graduating from engineering technology program is twice that of African American graduates from engineering programs. The statistical analysis confirmed that African Americans graduate from engineering technology programs at a higher percentage rate over engineering programs was statistically significant. The statistical analysis showed that no other ethnic group demonstrated this phenomena at a statistically significant level. Asians graduates did show a significant difference but in the opposite direction. Asian graduates completed degrees at a higher percentage from engineering programs over engineering technology programs. At a state by state level, the statistical analysis confirms that African Americans graduate from engineering technology at a significantly higher percentage rate than engineering programs. When comparing institutions that offered both engineering and engineering technology degree, the pattern continues even within the same institution.

Engineering technology graduates in the study's sample were hired as engineers as opposed to engineering technologists. This finding confirms previous research that found industry had not chosen to delineate between positions for engineering and for engineering technologists (Ungrodt 1982; NAE 2017). The data from the surveys indicated that both ET faculty and alumni strongly agreed that engineering technology graduates were hired as engineers. Many of the alumni survey respondents had not heard of engineering technologist positions. Though some alumni indicated that they had some difficulty in their careers, i.e. employers not knowing of engineering technology, due to their engineering technology degrees, the large majority indicated otherwise. Many ET graduates felt the engineering technology degree gave them a work advantage over

engineering graduates because of the hands on, applied nature of the engineering technology program.

Other factors attributed to the choice of engineering technology which include flexibility of the program offerings, accessibility (cost and location), and pedagogy. These factors are embedded into the actual degree programs themselves and the institutions that offer the degree program. Survey and interview participants consistently mentioned these factors as their reasons for choosing engineering technology over engineering. Very few participants listed all three as factors but most listed a combination of the three as impacting their choice of degree program.

6.1.2.1 Work Flexibility.

The factor of work flexibility relates to the time of day or the number of days per week a course is offered. Most of the engineering technology graduates in the study worked either part-time or full-time while achieving their degree. They found that the engineering technology courses accommodated their work schedules the best because they were offered at the time most convenient to them. Such flexibility included courses offered during the evening and courses which met less than three times a week. The present study reviewed the Fall 2016 engineering and engineering technology lectures courses in the departments of Mechanical Engineering, Electrical and Computer Engineering, Mechanical Engineering Technology, and Electrical and Computer Engineering Technology at Purdue, Georgia Tech, and SPSU which would be required for the first two years of the degree program. Engineering technology programs

Table 13 Fall 2016 lecture courses at Purdue, SPSU, and Georgia Tech

	Times of Class			Class Meetings per Week		
	Before Noon	Noon to 4:30 pm	4:30 pm or After	3	2	1
Mechanical Engineering (N=51)	43.1%	51.0%	5.9%	76.5%	23.5%	0.0%
Mechanical Engineering Technology (N=44)	34.1%	43.2%	22.7%	22.7%	50.0%	27.3%
Electrical Engineering (N=79)	48.1%	36.7%	15.0%	51.9%	48.1%	0.0%
Electrical Engineering Technology (N=51)	45.1%	25.5%	29.4%	23.5%	70.6%	5.9%

(Table 13) offer a larger percentage of their courses during the evening hours and a lower percentages of courses that require students to attend three time per week. This flexibility made the engineering technology programs more accessible to working students. The National Center for Education Statistics (2011) finds that 42% of African Americans pursuing an undergraduate degree work while they taking classes as opposed to 36% of Caucasian Americans. Combine these findings with the present study's data, flexibility

becomes a possible reason why an African American student would pursue engineering technology as a degree program. The study acknowledges that this conclusion is limited due to concentration on race as a single variable. Socio-economic status or class could be another attributing factor in this conclusion given the issue is having to work while attending college. Future research needs to focus on the intersectionality of race and class as it pertains to engineering technology.

6.1.2.2 Accessibility.

The two components noted within the accessibility factor were cost and location of degree offering. These two components, however, manifested themselves in a particular institution. Participants from SPSU indicated that cost of a major factor in choosing engineering technology while participants from Purdue indicated that location of degree offerings was key to choosing an engineering technology degree program at Purdue. These differences are related to the particular characteristics of each institution. The graduates of SPSU indicated that cost was a factor because they were comparing the costs between SPSU and the Georgia Institution of Technology (Georgia Tech). Georgia Tech's tuition and fee structure is significantly higher than SPSU.³³ In 2017-18, Georgia Tech's tuition and fees totaled \$12,418; while SPSU's tuition and fees were \$5,912. This tuition and fee differential, however, does not exist at Purdue, where the two degree programs costs the same. Graduates from Purdue, however, indicated that location of degree offerings was a factor in choosing the engineering technology degree program. Engineering technology

³³ Georgia Tech's tuition and fees <https://www.finaid.gatech.edu/current-cost-overview>. *Southern Polytechnic/Kennesaw State* <http://www.collegesimply.com/colleges/georgia/kennesaw-state-university/price/>

degree programs are offered at eight locations around the State of Indiana through a program called “Purdue Polytechnic.”³⁴ The Purdue engineering program is only offered on the main campus in West Lafayette. Again, the study acknowledges that this conclusion is limited due to concentration on race as a single variable. Socio-economic status or class could be another attributing factor in this conclusion given the issue is having to work while attending college. Future research needs to focus on the intersectionality of race and class as it pertains to engineering technology.

6.1.2.3 Hands-on Pedagogy.

The primary reason for choosing engineering technology for our survey respondents was the experiential, applied pedagogy described by most participants as hands-on learning. Not only was this applied pedagogy a reason for choosing engineering technology, many of the participants believed the knowledge and skills obtained through this instructional method prepared them better than their engineering colleagues for engineering workforce. This applied pedagogy is the primary way that engineering technology program differentiate their degree programs from engineering programs. Engineering programs are perceived to be more theoretical in preparation, while the engineering technology programs provide more hands on experience. This hands-on experience and pedagogy is made tangible by the numerous labs required in the engineering technology degree program that are not replicated within the engineering degree program. According to the deans at both SPSU and Purdue, many of the engineering technology courses are taught from a project based learning methodology so that students are able to

³⁴ <https://polytechnic.purdue.edu/locations>

apply their engineering theoretical knowledge (both mathematical and physical) to a real world problem. Purdue's Polytechnic system employs team based project learning because "Companies and communities rely on teamwork to achieve success. We practice it. From the first semester to the last, team projects are a cornerstone of Purdue Polytechnic programs, exposing students to team dynamics, deadlines, and problem-solving techniques."³⁵

Although not mentioned as a reason for choosing engineering technology, the fact that engineering technology does require less independent mathematic courses must be a factor. For individuals who are drawn to a more hands-on, applied educational experience, the prospect of additional independent, theoretical mathematics courses can be daunting. Many engineering technology programs embed mathematical instruction into particular engineering technology courses where they are needed (e.g. Dynamics requires an understanding of differential equations). One does not require an entire semester of differential equations to understand dynamics. The embedding of such mathematical instruction into particular courses makes the mathematical formulas more applied and less theoretical.

The study concludes that engineering technology is a potential pathway for African Americans into the engineering workforce, but it remains an unequal one when compared to those with an engineering degree. According to the study, the majority of the study's respondents were hired as engineers. The study's survey respondents indicate that their employers often prefer engineering technology graduates because of the hands-on, applied

³⁵ <https://polytechnic.purdue.edu/about/polytechnic-learning-environment>

experience they received during their educational instruction. Engineering technology programs are more accessible for students who must remain close to home or work while achieving their undergraduate education. The applied pedagogy of the engineering technology programs with its hands-on lab experiences and embedded mathematics was the key factor for both Caucasian and African American survey and interview participants. The study suggest that these factors lead to a larger percentage of African Americans enrolling and, most importantly, graduating from engineering technology programs (9.17%) as opposed to engineering programs (3.98%). As a result of these factors, engineering technology is a potential pathway for African Americans into the field of engineering, but does not equate with an engineering degree because several gatekeeping components exist.

6.1.3 The Gatekeeping Components

Engineering technology, however, also acts as a gatekeeper for graduates of its programs, including African Americans. The gatekeeping structures are not elements within engineering technology itself but reside in the overall political, social, and racist structure of the field of engineering. These gatekeeping structures subordinate engineering technology (its programs, degrees, faculty, and graduates) to a secondary place in the engineering hierarchy. The gatekeeping structures include racially stratified structure of engineering, theoretical instruction and abstract mathematical expertise as foundational values, limitations on or exclusion of engineering technology graduates, and branding of engineering technology as secondary in the field of engineering.

Theoretical instruction and abstract mathematics became foundational values of U.S. engineering because engineers needed to increase their social status in relations to scientists and business executives (see Chapter 1). Therefore in order to obtain funding from the government and the military industrial complex, leaders of U.S. engineering education after World War II seized upon the opportunity to move engineering toward a more scientific/theoretical and mathematical endeavor. The story of Frederick Terman, an engineer at the Radiation Laboratory at the Massachusetts Institute of Technology during World War II, illustrates this assertion. After the war, Terman became dean of engineering at Stanford and was determined that “engineers would not play second fiddle in the future” (Seely 1999:289). Seely (1999) asserts that Terman was not the only engineer irritated that physicists received most of the governmental military funding for research and most of the credit for wartime research accomplishments. Terman, however, also recognized that many engineers had been ignorant of the science underlying electronics and atomic weapons. Terman, along with others such as S.C. Hollister, organized a study committee on engineering education in the United States that resulted in the 1955 Grinter Report (Seely 1999). Seely (1999:291) asserts that the first draft of the Grinter report affirmed the need for more science and advanced mathematics in the study of engineering and proposed a two tiered system of engineering education: a professional-general program and a professional-science program. Flanigan and Porter (2015) summarized the committee’s view of the two tracks: The professional-general curriculum would allow for more ‘alternative choice’ of courses. Students in these programs would be trained in more problem solving engineering applications which would satisfy the needs of industry. On the other hand, the professional-scientific program would contain more math and science

preparation. The objective of this track would be to train engineers for research, development and design. Seely (1999:291) concluded that the committee who drafted the report assumed that most students would opt for the professional-general program which provided solid engineering training for jobs in industry. The committee believed that only a few elite engineering schools needed to develop advanced undergraduate and graduate programs in fundamental engineering science (professional-scientific) to prepare students for government and industrial research programs. Hollister, Terman, and the other leadership, however, rejected the two tiered model and adopted the professional-scientific model as the singular trajectory for U.S. engineering education. Those institutions which adopted this model would obtain more funding from the U.S. military and government and, therefore, universities were eager to cash in (Staton 2010). Because of the pursuit of government dollars and professional prestige, the scientific/mathematical model of engineering became the pattern for future engineering curriculum and the standard by which all other engineering programs, including engineering technology, would be measured. The theoretical/ mathematical pedagogy became foundation values of engineering in the United States.

Mathematics not only became a foundational value of engineering, it became the primary gatekeeper. Pearson and Miller (2012) determine that mathematics is the single, most important factor in determining a person's progression along the engineering pathway. These researchers determined that starting algebra early in one's secondary education and the completion of a calculus course in high school were key factors in predicting enrollment in engineering (2012:53). The completion of calculus courses was strongly related to the completion of a bachelor's degree in engineering (2012:54).

Mathematics had become the pathway into engineering. Using the theoretical underpinnings of this study, the elevation of mathematics to the key role of gatekeeper for engineering can be viewed as the usurpation of mathematics by the dominant group (white males) within engineering as a means of exclusionary closure (Parkins 1979:48) in order to bolster their perceived position of power/social status.

This focus on a theoretical scientific/mathematical model for engineering education has endured sharp criticism as the primary reason for the lack of diversity in the field of engineering. Respondents in a 1994 ASEE roundtable discussion reflecting on the Grinter Report acknowledge the accomplishments that emerged from the recommendations in the report but harshly criticize the white, male perspective of this recommendations.³⁶ One respondent notes that when the report was published there was serious unrest in the nation over racial and gender inclusion and “with this unrest and the knowledge that African-Americans, other minorities, and women were not welcome in a number of engineering schools, it is interesting that this issue did not make its way into the report” (Harris 1994:70). The respondent goes on to comment that “it is my belief, however, that there were those in leadership roles in the ASEE who could not believe, or foresee, that diversity in our profession would become an issue” (Harris 1994:70). Others (Chen 2009; NSF 2010; Staton 2010) have been critical of the theoretical pedagogy and independent advanced mathematical emphasis of current engineering curriculum.

³⁶ The present study notes that the respondents at the 1994 ASEE roundtable praised the Grinter Report for launching U.S. engineering education on its current trajectory and elevated the role of engineering in the post war era. The present study does not discount the advantages of the theoretical/scientific/mathematical model of engineering but argues that a singular model limits the potential of diversity within the field of engineering.

Although the survey and interview respondents indicated that they have experience limited barriers in their career because of their engineering technology degree, barriers do exist. These barriers manifest themselves in two concrete forms and one abstract form. The two concrete barriers are the criteria required for taking the PE exam and regulations in federal contracts concerning the hiring of engineers. The abstract barrier emerges from the hierarchical nature of the engineering field where engineering technology is seen as subordinate to engineer. Though the two concrete barriers offer tangible obstructions to certain engineering technology graduates, the view of engineering technology as subordinate to engineering affects all graduates with engineering technology baccalaureate degrees.

The PE license offers several advantages to an engineer but the primary one is that “only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients.”³⁷ The large majority of engineers who seek professional licensure are civil engineers. Pass rates from the October 2016 administration of the exam indicated that 59.3% of the exam takers were in the field of civil engineering as opposed to 11.83% from electrical engineering and 15.41% from mechanical engineering.³⁸ States are granted authority to oversee the licensing of engineers. The Society of Professional Engineers indicates that each “state has a different method of weighing unapproved engineering study, four-year engineering technology programs, four-year study in a science related to engineering, graduate study in engineering, the teaching of engineering, and engineering

³⁷ <https://www.nspe.org/resources/licensure/why-get-licensed/advantages-licensure>

³⁸ <http://ncees.org/engineering/pe/>

experience.”³⁹ Only 22 states (Appendix F) allow a graduate with an engineering technology bachelor’s degree to sit for the PE exam.⁴⁰ The states that do allow for an engineering technology graduate to take the PE exam require additional years of work-related engineering experience between 5–8 years of work-related engineering experience whereas the standard for graduates with an ABET-accredited engineering bachelor’s degree is 4 years. Many engineering technology programs, such as SPSU, have discontinued their civil engineering technology programs because their graduates cannot receive state licensure in states surrounding Georgia and therefore cannot practice as a licensed civil engineer in those states.

At the federal level, the Office of Personnel Management oversees the recruiting of individuals for federal jobs and sets policy for hiring. The policy for engineers who work for the federal government (GS-0800) states that the basic requirement is a bachelor’s degree in engineering from an ABET-accredited program. By omitting engineering technology from this qualification standard, the federal government, as a legal and authoritative national entity, delegitimizes it as a qualified degree program (NAE 2017:28). Also the Department of Labor classifies engineering technologists as occupations that are subject to Fair Labor Standard Act (FLSA) rules on issues such as minimum wage while engineers as an occupation are exempt from the FLSA rules because they are classified as “a learned profession” (NAE 2017:28).

³⁹ <https://www.nspe.org/resources/licensure/resources/faq#other%20ways%20to%20qualify>

⁴⁰ This information was retrieved from each states professional licensing website. Alabama does allow graduates holding bachelor’s degrees in engineering technology to take the PE exam but they must have a master’s degree in engineering as well.

Historically, engineering technology struggled with its identity, especially in relation to engineering. The perception of its subordinate nature creates a detrimental barrier within the field of engineering. Chapter 1 discusses the importance of prestige and status within the field of engineering. A key historical example of this concern for prestige led to the creation of the engineering technology division of the ASEE. When engineering technology programs were moving from 2 year associate degree programs to 4 year bachelor degree programs, the deans of engineering voiced their concern. They believed that baccalaureate engineering technology degrees were an encroachment on the professional degree programs of engineering (O'Hair 1995:214, 265). The engineering deans were opposed to allowing engineering technology academics into their departmental divisions at ASEE. They exerted their political power and prevented the inclusion of engineering technology faculty and professionals into their division within ASEE. Therefore, engineering technology practitioners had to develop their own Engineering Technology division within the organization (O'Hair 1995:281). Chapter 2 describes the interplay between power, knowledge, and expertise of engineering technology and its constant boundary work with engineering. The chapter recounts the numerous attempts at boundary work and the difficulty that engineering technology has in comparing itself to and delineating itself from engineering. Engineering technology as both an education degree program and a career pathway remains in a state of flux within the field of engineering. The inability to effectively delineate between these academic programs places engineering technology in a precarious position where it must constantly be defining and managing these boundaries. Therefore, engineering technology suffers, as an academic and economic discipline, from a lack of clarity about what it is, what its graduates

do, and confusion about the boundaries between it and its more powerful and well-known discipline, engineering. The opposition raised by the engineering deans was an attempt at imposing social closure and thereby protecting their monopolization of power. The four-year baccalaureate degree had been the mechanism of control that maintained engineering's power over the other tiers of engineering. Engineering technology breached that mechanism of control but other controls were maintained. Engineering technology's inability to breach these new controls such as separate accreditation reviews, PE licensing, and the federal contract demonstrates its subordinate role to engineering.

6.2 Application of Theoretical Perspectives

An analysis of the findings and conclusions of this study using the theoretical lens of critical race theory and the Weber's concept of status group guides our understanding of the tiered hierarchy of the field of engineering as a manifestation of power distribution. In applying Weber's concept of status group, one begins to understand how engineers as a status group have employed Parkin's concept of social closure to close or restrict access to the top level of the engineering hierarchy through a series of exclusionary practices including Collins' idea of educational credentialism. Elements from CRT are employed as an analytical framework in assessing the findings and conclusions of the study that 1) acknowledges that racism is endemic, 2) recognizes racism as dynamic and mutable in its societal expressions, 3) expresses skepticism when confronted with objectivity, colorblindness, and meritocracy, and 4) recognizes the validity of experiential knowledge of people of color. When these elements of critical race theory are applied to the findings and conclusions, an argument can be made that these attempts of social closure to the upper levels of engineering are deemed racist.

Weber's concept of status group describes the power distribution within the hierarchical field of engineering and engineering's need to maintain a high level of occupation prestige. The levels within the hierarchical structure of engineering can be classified as status groups (Weber 1978)⁴¹ and access to particular levels are based on the obtainment of specialized knowledge and expertise, educational credentials, and professional licensure. Historically, engineers have sought to increase their occupational prestige and economic social status by increasing academic credentials deemed important by the scientific community and extending their control over the business operations of construction, manufacturing, and technological development through the requirement of professional certification. World War II provided the impetus for this change.

As stated in the previous paragraphs the final Grinter Report reflected this need to increase the social status of engineers through scientific academic credentials by recommending a singular pathway to an engineering degree that included increased requirements in science and mathematical courses as well as a move away from applied engineering to theoretical engineering. The final report, however, ignored the original recommendation of the committee which was dual pathways to an engineering degree that included a scientific/theoretical path and a practical/applied path. By ignoring the recommendation of the committee, the leaders of engineering education created further exclusionary barriers to the top level of engineering. As Janelle Monae, who portrays Mary Jackson in the film Hidden Figures, complains, "Every time we have a chance to get ahead

⁴¹ For Weber's closure theory, see especially pp. 43-6, 302-7, 339-48, 635-40, 926-55 in Economy and Society.

they move the finish line. Every time.”⁴² In an ASEE Roundtable discussion of the Grinter Report (Harris 1994), several of the panelists note that the report was produced in a racially charged period of U.S. history so why does the report not address the issue of race at all. And yet the decisions made in 1955 by the leadership of the American Society of Engineering Education have adversely affected African Americans’ ability to ascend the engineering hierarchy for the past six decades.

The curriculum changes along with other mechanisms of control are examples of how engineering uses social closure to limit access to the top level of engineering. Social closure refers to the monopolization of power to enhance or protect a group’s social position, status, or rewards through two processes of exclusion and usurpation (Parkin 1979). The dominant engineering group employed exclusionary practices in order to “secure for itself a privileged position at the expense of some other group through the process of subordination” (Parkin 1979:45). Based on the findings and conclusions of this study, these exclusionary practices include degree credentials and professional licensing which are essential for membership in each tier and migration within the field of engineering. Murphy (1984:550) asserts, “Education, like ethnicity and social class, is conceived as a status culture that often has little proven relationship to on-the job performance and to that extent it is a cultural rather than a job performance basis of exclusion from work position.” Weber argues that the desire for regularized curriculum and specialized licensing is not a ‘thirst for education’ but the desire to limit the supply of candidates for these positions and, therefore, the monopolization by the owners of

⁴² Quote from the 2017 movie “Hidden Figures” based on the book by Lee Shetterly, M. 2016. *Hidden figures: The American dream and the untold story of the African women mathematicians who helped win the space race*. New York, NY: William Morrow.

educational certificates. He views the 'examination' is the universal means of this monopolization (1978:1000). Education and licensing as exclusionary codes are important because the level and type of educational credentials possessed by an individual reflects membership in a certain status group and the members of the particular status group control membership within the group through the process of employment (Collins 1971:1012). African Americans have been disadvantaged due to these exclusionary practices. The increased levels of mathematics excludes many African Americans students who did not have access to adequate preparation in mathematics or attend high schools that did not have adequate resources to offer advanced math courses. The shift from teaching engineering from an applied, hands-on pedagogy to a theoretical pedagogy acts a disadvantage to many African American students who prefer an applied, experiential pedagogy (NAMCE 2011; McDougal 2009; Tsui 2007; Moore 2005; Fazarro & Stevens 2004). Each of these exclusionary practices limits the migration of African Americans into the top tier of the engineering field.

Critical Race Theory holds that racism is endemic within a social structure and decisions made within those social structures do include racist considerations. The decision to not accept the second recommendation of the Grinter Report, therefore, could be interpreted as racial discrimination. The elimination of an applied, practical engineering track may have been to increase the status of the engineer. That decision may have been in attempt to propel American engineering toward more scientific discovery and innovation like their recent German adversaries. But why advocate for the single educational pathway of a more scientific/theoretical and mathematical engineering and not a dual pathway that included a more practical and applied form of engineering education? Mathematical

proficiency and theoretical pedagogy are values of the dominant white male and their decision to select this single pathway to an engineering degree has resulted in a limited number of African Americans receiving engineering degrees.

CRT sees racism as endemic within our society because of the dynamic nature of racism and its ability to mutate within the culture. Racism becomes more subtle in its expressions. The idea of providing a possible pathway into the field of engineering for African Americans but one that is unequal compared to the predominately white, male pathway is a mutation of institutional racism. When individuals are limited to a particular degree program because they have to work while attending college, attend part time instead of fulltime, or cannot relocate and these circumstances are disproportionally affecting a particular racial group, again one sees the mutable form of institutional racism.

CRT questions meritocratic systems and views with skepticism any claims of objectivity. Yet, this system of credentialing engineers is strongly based on one's ability to interact successfully with what the dominant group maintains as the most objective and meritocratic subject in the curriculum: mathematics. It is in the elevation of mathematics within the curriculum that engineering obtains an increased prestige in relation to science. CRT would label the need for increased mathematics in the engineering curriculum as unnecessary and a means of limiting African Americans access to the top level of engineering. CRT holds that the experiential knowledge of people of color is a legitimate means of determining reality and would look to this study's findings that a significantly larger percentage of African Americans graduate from engineering technology programs as evidence of engineering technology as a successful pathway for African Americans into the field of engineering.

The intersection of the Weber's concept of status groups and CRT are the mutable forms of racism expressed as mechanisms of social closure. In the previous cited research, the mechanisms of social closure include both the institutional racist structures of inadequate mathematical and science preparation, lack of facilities and courses due to low tax revenue districts, and lack of representative mentors and the discrimination of individuals who hold that black students are intellectually adequate for engineering or that these students must "prove" themselves worthy. In the current study, the mechanisms of social closure include providing a potential but unequal pathway into the field of engineering and the creation of accessibility constraints which funnel African Americans away from engineering programs and into engineering technology.

6.3 Limitations

The study employs both full data sets and purposeful samples in its data collection. The IPEDS data set includes graduation, demographic, and institutional data from all institutions with engineering technology programs in the United States. Since the data set was used in its entirety as opposed to sample of the data set, the findings from the data and the statistical analysis of the data can be generalized to engineering technology education in the United States.

The data from the surveys and interviews, however, do not constitute a representative sample. The data sample of only two institutions and the small response rate is limiting. The data from the surveys and interviews in the present study were collected from a purposive sample. A purposive sample is a non-representative subset of some larger population, and is constructed to serve a very specific need or purpose. A

researcher may have a specific group in mind, African Americans in the current study. The researcher will attempt to focus on and select from the target group. The study sought to utilize institutions which had both engineering and engineering technology programs and graduated a significantly large number of engineering technology graduates. These two institutions cannot be assumed to be representative of the all institutions offering engineering and engineering technology degrees.

The interview participants self-selected to participate in the interview process and, therefore, were not randomly selected. The interview sample contains a larger number of African American respondents because the purpose of the study was to gauge the role of engineering technology of Africans Americans in the field of engineering. The researcher chose to interview participants who were African Americans in order to elicit a good number of responses from this particular population. So the results and conclusions drawn from the survey and interview data prohibit its generalizability to the entire engineering technology community.

The study focused on African Americans and the results are not representative of other underrepresented ethnic populations in the field of engineering, though the study does provide a framework for such research. The study also choose to focus solely on race which does not address the complicated interaction between the intersectionality of race, gender, class, and sexuality. The study acknowledges that class or socio-economic status could demonstrate a significant intersectionality with race on the issues of work flexibility, cost, and location accessibility.

6.4 Contributions to the Field

The study makes a contribution to several areas of sociology of science and technology studies. The field of engineering technology has received little research attention. This study, along with the recent publication from the NAE (2017), begin to shed light on the field of engineering technology and its role within the field of engineering. The study confirms the lack of diversity in the field of engineering and though this study focused solely on African Americans, the study's methodology provides a possible framework for studying other underrepresented populations and their relationships to the field of engineering.

The study contributes an additional dimension to the debate on how to broaden the participation of African Americans into the field of engineering. Previous studies and research on increasing the number of African Americans in engineering have focused solely on an engineering degree as the pathway into the field of engineering. The present study provides a different perspective and an additional pathway that may avoid a number of the obstacles faced with an engineering degree. The study highlights institutional structures that serve as barriers to African Americans from enrolling and graduating with an engineering related degree such as cost, work flexibility, and pedagogy that goes beyond the tradition research on mathematical preparation and lack of mentors.

The study provides additional confirmation that educational degrees are a major form of credentialism and that such credentialism can be used as an exclusionary device of social closure. In reference to the theoretical tenets of CRT, the study suggests that mathematical curriculum requirements are a form a codified "law" in the engineering

educational system. The experience of African Americans in engineering technology and their connections to the field of engineering gives the CRT's idea of voice to African Americans and their interactions with engineering.

6.5 Future Direction

Future research within engineering technology is fruitful because of the dearth of current research in the area. Future research could expand the sample size to include institutions from other regions within the United States which offer engineering technology programs. Though the analysis and conclusions from the IPEDS data indicates similar patterns of higher percentages of African Americans graduating with engineering technology over engineering degrees across of regions, the reasons why Africans Americans are drawn to engineering technology may differ by region. Other potential directions include applying the similar research methodology to other demographic variables such as gender. It appears from the IPEDS data that the percentage of women in engineering technology is actually less than in engineering across the United States. Why are women even less attracted to engineering technology than engineering? Clearly, the study needs to be expanded to study additional ethnic populations and their experiences with the field of engineering. The framework of the study can be applied to other underrepresented groups to determine if these groups experience the same pathway or gatekeeper roles of engineering technology as African Americans. Trends similar to those of African Americans can be seen in the ethnic populations of Hispanics and Native Americans. These trends, however, are counterintuitive with the Asian population as a whole, but particular subgroups of the Asian population may also be underrepresented. Finally, the results of the study suggest that socio-economic status or class could be a

significant factor in who chooses engineering technology as a field of study. Do students from less affluent or “blue-collar” backgrounds gravitate more toward engineering technology for similar reasons such as cost, work flexibility, and pedagogy? The idea of work flexibility in engineering education also deserves further investigation to determine role of work flexibility and the expectations of being a full-time or part-time students in engineering education.

6.6 Conclusions

This study argues that a workforce with technological knowledge and expertise is vital to the continued growth of the United States economy. This study documents the need for an increase in U.S. production of qualified engineers (Jobs Council 2011:20; NRC 2007; NSF 2014) by both increasing the number of individuals entering engineering education and increasing the retention and graduation rates of these individuals. The study argues that technology reduces the value of global location thus an increasingly technological workforce is necessary for the United States to maintain a leadership role in the global economy (NRC 2007:3; Jobs Council, 2011; NSF 2014). The study argues that the field of engineering must become more diversified because of the global synthesis of economies and technological development and because the U.S. is not fully utilizing its intellectual and physical workforce (Slaughter, Tao, & Pearson 2015; NSF 2014; Leggon & McNealy 2012; NRC 2007). The study demonstrates that engineering has not embraced diversity which suggests that its impact on economic growth and innovative competitiveness has been hampered and its impact on global economic development is being negatively affected by the “social destabilizing effect of cultural polarization” (Ager & Buckner 2013:96). Furthermore, the study demonstrates that engineering provides a

pathway to upward mobility in our society, but African Americans have not experienced such upward mobility because they are disproportionately underrepresented in the field of engineering.

If the United States wants to increase its number of qualified engineers and wants to increase the number of African Americans as qualified engineers then engineering technology is a possible solution, but only if engineering technology is raised to the level of engineering in the matter of status, pay, and career attainment. The present study presents the following policy recommendations for consideration: 1) modify the policy of GS-0800 Engineering Qualification Standard within the U.S. Office of Personnel Management to include graduates from ABE-accredited engineering technology degree programs, 2) allow graduates with ABET-accredited engineering technology degrees access to professional licensure, and 3) consider elevating engineering technology to the level of applied engineering (with the appropriate curricular changes) and fulfill the original recommendation of the Grinter Report. The first two recommendations are currently being pursued by the Engineering Technology Council of the ASEE.⁴³ The third is a recommendation of this study.

The Office of Personnel Management oversees the recruiting of individuals for federal jobs and sets policy for hiring. The hiring policy for engineers who work for the federal government is GS-0800. This policy states that the basic requirement for a GS-0800 position is a bachelor's degree in engineering from an ABET-accredited program.

⁴³ Many thanks to Dr. Ronald Land of Purdue for providing this information and leading the effort on behalf of the Engineering Technology Council.

The federal government as a legal and authoritative entity currently delegitimizes engineering technology as a qualified degree program because of its omission of engineering technology from this qualification standard and thus perpetuates the engineering hierarchy. The policy change recommended by the Engineering Technology Council is that a bachelor's degree in engineering technology from an ABET-accredited program be added to the qualification standards. The ETC recognizes that the GS-0800 policy is an entry level requirement for federal engineering jobs and that more specialized jobs would require additional experience and/or education. Their position statement "seeks only to open the first door, with the full understanding that it is up to the individual to advance from there (ETC 2016). The addition of engineering technology to this qualification standard helps to legitimize engineering technology as an appropriate degree in the field of engineering, validates the degree program as a legitimate pathway to a career in engineering, and helps to dissolve the barrier between the second and first tier of the engineering hierarchy.

The professional licensing of engineers is regulated at the state level. Currently a large number of states do not allow graduates with degrees in engineering technology access to the PE examination. Those states that do allow engineering technology graduates to sit for the exam stipulate additional requirements such as work experiences or graduate work which are not required for graduates with engineering degrees. The policy recommendation of the ETC is to treat graduates with ABET-accredited bachelor's degree in engineering technology the same as graduates with engineering degrees and allow them to take the exam without any additional requirements. Though a minority of engineers seek the PE license, the act of licensing is a form of legitimation. The license is regulated

and conferred by a legal, authoritative body (in this case, state government). The license grants the individual the ability to perform certain duties or acts that have been legally prescribed by law but it also bestows upon the individual an elevated prestige within the engineering profession based on the granted authority. As before, to deny an individual access to professional licensing based on the degree held by that individual not only delegitimizes the individual but the degree program as well. And why would some states accept a certain degree while other states do not? Do the laws of physics or engineering techniques vary from state to state? No, state regulation criteria are the result of political lobbying and economic interests.

Scholars, activists, corporations, and government officials have sought multiple means to increase the number of African Americans in engineering.⁴⁴ Unfortunately, these attempts have not significantly increased the percentage of African Americans in engineering education or the field of engineering. This study proves that African Americans enroll and graduate at a significantly higher percentage from engineering technology degree programs than from engineering programs. The present study also demonstrates that for the survey and interview participants engineering technology is a potential, yet still unequal, pathway to a viable career in the engineering workforce. The present study recommends that engineering technology be elevated to the educational degree status of applied engineering with the appropriate curricular changes. The recommendation brings back the original recommendation of the Grinter Report committee that the United States create an engineering educational system with two pathways into the field: one scientific/theoretical and one practical/applied. These two pathways would need

⁴⁴ See Slaughter, Tao, and Pearson (2015) for the most recent summary of such opportunities.

to lead to similar economic and status rewards within the field of engineering. This elevation also could aid in remedying the mutable forms of racism that have acted as mechanisms of social closure for African Americans. The advantages of such an engineering educational system include the accommodations of multiple pedagogies (applied versus theoretical, abstract versus embedded mathematics), an educational system that is more correctly aligned with the industry, a flattening of the engineering hierarchy, and a legitimized and equal pathway into engineering that better aligns with the life experiences of African Americans.

APPENDIX A. CONSENT FORM FOR ELECTRONIC SURVEY

Dear Participant,

You are being asked to be a volunteer in a research study. Georgia Tech IRB Protocol H14261

Purpose:

The following survey is part of a research project being carried out by Ron Dempsey, a graduate student at Georgia Institute of Technology. The research project examines the relationship between engineering and engineering technology and the role that engineering technology programs play in the education of underrepresented minorities.

Exclusion/Inclusion Criteria:

This study will be interviewing faculty from your institution who serve as faculty members in the areas of engineering or engineering technology.

Procedures:

If you decide to participate, you will be asked to complete the online survey which will take between 20-30 minutes to complete.

Risks or Discomforts:

The researchers anticipate that no risks are involved and you will experience no discomfort.

Benefits:

You are not likely to benefit in any way from joining this study. We hope that what we learn will someday help underrepresented minorities who are entering the fields of engineering understand the challenges and obstacles that await them.

Compensation to You:

You will not be compensated for this research study.

Confidentiality:

The online survey is anonymous. You will be asked if you would like to participate in a follow-up interview at the end of the survey. If you chose to participate in the follow-up survey then you will be asked to provide your name and email address so you can be contacted. Your name and email address, however, will NOT be associated with your online survey responses.

Costs to You:

There are no costs to you, other than your time, for being in this study.

In Case of Injury/Harm:

If you are injured as a result of being in this study, please contact Dr. Willie Pearson, Ph.D., at telephone (404) 771-5538. Neither the Principal Investigator nor Georgia Institute of Technology has made provision for payment of costs associated with any injury resulting from participation in this study.

Participant Rights:

- Your participation in this study is voluntary. You do not have to be in this study if you don't want to be.
- You have the right to change your mind and leave the study at any time without giving any reason and without penalty.
- Any new information that may make you change your mind about being in this study will be given to you.
- You will be given a copy of this information form to keep.
- You do not waive any of your legal rights by agreeing to be in this study.

Conflict of Interest:

The research team knows of no conflict of interest in this research study.

Questions about the Study:

If you have any questions about the study, you may contact Dr. Willie Pearson at telephone (404) 771-5538 or at willie.pearson@hts.gatech.edu or Dr. Ron Dempsey at telephone 678-915-7364 or at Dempsey@spsu.edu.

Questions about Your Rights as a Research Participant:

If you have any questions about your rights as a research participant, you may contact

Ms. Melanie Clark, Georgia Institute of Technology

Office of Research Integrity Assurance, at (404) 894-6942.

[or]

Ms. Kelly Winn, Georgia Institute of Technology

Office of Research Integrity Assurance, at (404) 385- 2175.

If you complete the online survey, it means that you have read (or have had read to you) the information contained in this letter, and are indicating their consent to participate in this research study.

Thank you,

Ron Dempsey

APPENDIX B. FACULTY AND ALUMNI SURVEYS QUESTIONS

Engineering Technology Faculty Survey Questions

1. Where are you currently a faculty member?
2. Are you a member of the engineering technology faculty, the engineering faculty, or both?
3. What is your professorial rank?
4. Are you tenured?
5. How many years have you been at your current institution?
6. In regards to the curriculum requirements in engineering related courses for your institution's engineering and engineering technology programs, are the programs similar or different?
7. In regards to the level of difficulty (academic rigor) for your institution's engineering and engineering technology programs, are the programs similar or different?
8. Do graduates from your engineering and engineering technology programs pursue similar or different job opportunities?
9. Are graduates from your engineering technology programs hired as engineers, engineering technologists, or engineering technicians?
10. The Engineering Technology Council of ASEE has adopted the slogan "The degree is Engineering Technology, the career is engineering." Do you agree or disagree with this statement?
11. What is the future of engineering technology?
12. Are you male or female?
13. What is your ethnicity? (Please select all that apply.)
14. What is the highest level of education you have completed?

Engineering Technology Alumni Survey Questions

1. What institution did you graduate from?
2. Why did you choose an engineering technology degree as opposed to an engineering degree?
3. In regards to the curriculum requirements in engineering related courses for your institution's engineering and engineering technology programs, are the programs similar or different?
4. In regards to the level of difficulty (academic rigor) for your institution's engineering and engineering technology programs, are the programs similar or different?
5. Do graduates from your engineering and engineering technology programs pursue similar or different job opportunities?
6. Are graduates from your engineering technology programs hired as engineers, engineering technologists, or engineering technicians?
7. The Engineering Technology Council of ASEE has adopted the slogan "The degree is Engineering Technology, the career is engineering." Do you agree or disagree with this statement?
8. What is the future of engineering technology?
9. Are you male or female?
10. What is your ethnicity? (Please select all that apply.)
11. What is the highest level of education you have completed?
12. What is your current job title? If retired, what was your job title upon retirement?

**APPENDIX C. RECRUITMENT EMAILS SENT TO
FACULTY AND ALUMNI**

Alumni Survey

Dear Purdue University Engineering Technology graduate,

“BRIEF INTRO PARAGRAPH about THE DEPARTMENT if you would like”

I would like for you to participate in a national survey of engineering technology alumni. You will be joining other engineering technology alumni from Purdue, Rochester Institute of Technology, and Southern Polytechnic State. This survey is important to the future of engineering technology.

The survey should only take 20 minutes to complete. You can access the survey by clicking on the following link: <https://www.surveymonkey.com/s/ETAlumni> or by copying the URL link into your browser.

Your responses will be kept confidential while the survey is analyzed. After that, all surveys will be destroyed along with all identifying information.

Thank you again for your assistance.

Faculty Survey

Colleagues,

I invite you to participate in a survey on minority students in engineering technology. This survey will be administered to ET faculty at Southern Polytechnic State, Purdue University, and Rochester Institute of Technology.

The survey should take about 20-30 minutes to complete. I appreciate your willingness to assist me with research project.

Please click this link to begin the survey: <https://www.surveymonkey.com/s/etfaculty> or copy and paste the URL into your browser.

APPENDIX D. ALUMNI INTERVIEW QUESTIONS

Alumni Interview Questions

1. Why did you choose engineering technology has a degree program instead of engineering?

2. While you were at your institution, did you observe any form of discrimination against minority students or female students?

3. Did you face any challenges in your career because you had an engineering technology degree as opposed to an engineering degree?

4. Minority students gravitate toward engineering technology as opposed to engineering. Why do you think engineering technology is more appealing to minority students than engineering?

**APPENDIX E. AFRICAN AMERICAN GRADUATES OF ENG AND
ET PROGRAMS BY STATE (2014)**

Table 14 African American graduates of engineering and engineering technology programs by state (2014).

State	% grads in ENG	% grads in ET	# of grads in ENG	# of grads in ET	State	% grads in ENG	% grads in ET	# of grads in ENG	# of grads in ET
AK	1.48	0.00	2	0	MT	0.00	0.00	0	0
AL	11.68	15.58	213	108	NC	10.43	14.71	220	99
AR	3.30	38.10	18	48	ND	1.01	0.00	4	0
AZ	2.30	3.40	36	7	NE	2.20	0.00	8	0
CA	1.91	4.35	206	53	NH	0.00	1.23	0	2
CO	1.34	4.27	32	10	NJ	4.02	12.07	77	28
CT	3.57	8.45	30	18	NM	1.77	0.09	9	1
DE	7.35	20.00	15	2	NV	0.75	15.38	2	4
FL	6.92	17.06	269	73	NY	3.50	10.06	208	126
GA	7.38	34.08	175	137	OH	3.30	6.56	131	50
HI	0.00	0.00	0	0	OK	3.89	4.76	39	20
IA	1.36	2.68	19	4	OR	0.09	3.75	9	5
ID	0.06	0.00	3	0	PA	2.91	3.37	160	29
IL	2.97	10.58	95	75	RI	2.59	6.49	8	5
IN	1.91	4.58	53	46	SC	8.65	39.82	80	45
KS	1.40	4.37	13	15	SD	0.00	2.15	0	2
KY	2.75	4.66	19	20	TN	5.83	14.58	77	48
LA	8.10	19.37	89	67	TX	4.44	10.45	290	122
MA	3.24	4.95	112	19	UT	0.00	2.46	0	3
MD	9.14	18.57	173	13	VA	6.26	29.23	171	140
ME	0.37	1.80	1	3	VT	1.30	0.00	2	0
MI	2.61	7.98	97	70	WA	1.85	3.40	32	9
MN	2.56	4.76	33	7	WI	1.01	1.25	20	4
MO	3.83	61.00	7.71	32	WV	3.30	1.14	15	2
MS	14.93	36.36	73	68	WY	0.00	NA	0	NA

**APPENDIX F. STATE REQUIREMENTS TO TAKE THE
PROFESSIONAL ENGINEERING EXAM FOR ET GRADUATES**

Table 15 State requirements to take PE Exam for engineering technology graduates

State	Degree Required	Years of Work Experience Required with ET Degree
AL	4 Year Eng. Technology Degree W/ABET	6
	MS Eng. Degree	
	4 Year ABET Eng. Technology Degree (prior to 2015)	8
AK	4 Year ABET Eng. Technology Degree	6
AZ	No ET	
AR	No ET	
CA	4 Year Eng. Technology Degree W/MS	1
	or PHD in Eng. Degree	
	4 Year ABET Eng. Technology Degree	6
CO	4 Year ABET Eng. Technology Degree	6
CT	No ET	
DE	4 Year ABET Eng. Technology Degree	8
FL	NO ET	
GA	4 Year ABET Eng. Technology Degree	7
HI	4 Year ABET Eng. Technology Degree	8
ID	No ET	
IL	No ET	
IN	No ET	
IA	No ET	
KS	No ET	
KY	No ET	
LA	No ET	
ME	4 Year ABET BS Eng. Technology Degree	5
MD	No ET	
MA	4 Year ABET BS Technology Eng. Degree,	8
MI	No ET	
MN	No ET	
MS	No ET	
MO	No ET	
MT	No ET	
NE	No ET	
NV	No ET	
NH	4 Year ABET BS Eng. Technology Degree	8
NJ	4 Year ABET Eng. Technology Degree	6
NM	4 Year ABET Eng. Technology Degree	6

NY	4 Year ABET Eng. Technology Degree	6
NC	4 Year ABET Eng. Technology Degree	8
	2 Year Eng. Technology Degree	10
ND	No ET	
OH	No ET	
OK	No ET	
OR	4 Year ABET BS Eng. Technology Degree	6
PA	No ET	
RI	4 Year ABET BS Eng. Technology Degree	6
SC	4 Year ABET BS Eng. Technology Degree	8
SD	4 Year ABET BS Eng. Technology Degree	5
TX	4 Year ABET BS Eng. Technology Degree	8
TN	No ET	
UT	No ET	
VT	4 Year ABET BS Eng. Technology Degree	8
VA	4 Year ABET BS Eng. Technology Degree	6
WA	No ET	
WV	No ET	
WI	2 Year Eng. Technology Degree	6
WY	No ET	

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