AC 2011-1441: CRITICAL THINKING INSTRUCTION AND

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Dr. Annette Mallory Donawa resides in Maryland with her husband and two children. She received her Bachelor's and Doctoral degrees from higher education institutions in Maryland: Towson University and Morgan State University. She received her Master's degree from Illinois Northern Illinois University. Dr. Donawa has more than 25 years of experience comprising of K-12 and higher education, corporate training, and human resources. Her doctoral research focused on examining the outcomes of critical thinking instruction with minority engineering students. Dr. Donawa's goal is to continue her research in critical thinking to broader audiences, having a greater impact on student retention and graduation rates. Dr. Donawa has travelled extensively throughout the US and West Africa where she has trained corporate and government personnel. She feels honored to have presented her research on critical thinking for ASEE in Chicago (2005) and Hawaii (2008).

THE IMPACT OF CRITICAL THINKING INSTRUCTION ON MINORITY ENGINEERING STUDENTS AT A PUBLIC URBAN HIGHER EDUCATION INSTITUTION

Introduction

Students attend higher education institutions with an expectation that they will benefit from knowledge acquisition and develop an expertise in a designated discipline[1] (Tsui, 2003). In that vein, the major goals of higher education are to cultivate critical thinkers [2, 3, 1] (Tsui, 1998, 1999, 2003). The role of higher education is becoming increasingly demanding, given the criticism that K-12 educational systems are not preparing students to think beyond rote memorization[4] (Darling-Hammond, 2000). Learning in higher education institutions, however, is thought to be qualitatively different from learning at earlier levels of education[5] (Dubuc, 2000).

Developing critical thinking skills among young African American students, especially those entering college for the first time, has evoked a sense of urgency[6] (Donawa, 2009). For example, the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) shared common observations about educational disparities in STEM disciplines as related to African American students and have called for more intense research to study these issues.

Many studies and reports have been written which indicate that African Americans need to be afforded extra efforts in critical thinking skills because of commonly observed educational disparities[7, 8] (Darling-Hammond, 2000; Jibrell, 1990; Schorr, 2002). In one study, the developments of critical thinking skills were linked to class origins (Tsui, 2003). In her study, disparities were found in educational, cultural, and social capital when comparisons were made between students from higher socio economic status backgrounds and those from lower socio economic status backgrounds. Parents from the elite class tended to be engaged in professional, white-collar positions where there was a demand or the allowance of frequent exercise of critical thinking skills and decision-making opportunities (Tsui, 2003). Schorr (2002), who authored a three-year qualitative study on a charter school in East Oakland, California, realized the real problem with schools in major cities was that race and income in America determined how well children performed in school.

NSF (2007) reported that in 1994, out of the 95.9% of science and engineering Bachelor's degrees awarded, only 8.4% were awarded to African Americans, while 65.1% were awarded to Caucasians[9]. The American Society for Engineering Education's (ASEE) publication, "Profiles of Engineering and Engineering Technology Colleges" (2008) supports the data in the NSF (2007) report[10]. In 2006, 5.0% of African Americans earned Bachelor's degrees, compared to 66.7% of Caucasians. From this set of data, researchers are cautioned about the need to better understand the low numbers of African American students earning degrees in

STEM disciplines (Donawa, 2009). STEM disciplines became the focus of this study as the researcher seeks to relate these disparities among African American students and critical thinking.

The shortage of African Americans earning college degrees affects the nation as a whole. Reported achievement gaps by Fleming, Garcia & Morning (1995); Fleming & Morning (1998); McDonald & Powell (1998); Lee (1986); Garibaldi (1997); and Jibrell (1990), have demonstrated that White students scored 30 percent higher than Black students taking the National Assessment of Educational Progress (NAEP) science and reading and writing scores [11, 12, 13, 14, 15]. Exposing students to critical thinking pedagogies in the K-12 education systems and higher education institutions can narrow the academic achievement gap for African American students (Donawa, 2009).

As a precursor to understanding those disparities, examining and understanding the history of higher education is helpful. Overall, the American education system was developed to assimilate and influence a highly selective group of people – white males in proper morals and manners, which primarily included Bible instruction [16, 17, 18] (Cohen, 1988; Donawa, 2007, 2009; Gordon & Browne, 2004). The education of minorities and women were not taken into consideration when policies and procedures were established for higher education institutions in America. Minority students, opposed to other populations, are school dependent and needed access to the best schools, resources, and access to the best teachers (Donawa, 2009). In fact, minority students needed the most support from educational systems, but were unlikely to receive adequate educational support.

Historically and currently, mass education is aimed at producing minimal levels of competence, and a large majority of African American students attend public schools. This means that racial minorities were "systematically excluded or separated" from receiving critical thinking instruction (Fleming, Garcia, & Morning, 1996, p. 438-9). Since minority students were not getting the exposure to critical thinking skills in K-12 public education institutions, they entered the higher education realm under prepared academically. Providing skills courses and individual assistance could assist students to make the cognitive connections needed[19] (Stark & Lattuca, 1997).

Purpose

The researcher was motivated to conduct the research study as a result of her work with higher order thinking skills (HOTS) 25 years ago at a regional educational laboratory in Chicago, Illinois. The purpose of this research study was to examine whether a critical thinking intervention would increase students' critical thinking skills. This study was conducted over a three-year period as a mixed methods, quasi–experimental design examining STEM students' critical thinking skills at a Historically Black College and University (HBCU). A standardized critical thinking test, the Cornell Critical Thinking Test, was administered to students entering the Pre-Freshmen Accelerated Curriculum in Engineering (PACE) program from 2006-2008 at Morgan State University. In addition to pre- and post-assessment test scores from the Cornell Critical Thinking Test, the researcher added a qualitative inquiry to the study which looked at faculty and students' perceptions of critical thinking. The researcher was curious about

individual student's perception of the critical thinking intervention and the manner in which the engineering faculty perceived the importance of integrating critical thinking into engineering curricula.

The overarching goals of this research were to: provide a critical thinking course that would increase students' post- test scores on a standardized critical thinking test; provide minority engineering students with critical thinking and cognitive tools that could be applied inside and outside of the classroom environment; and create adaptable, life-long learners and problem-solvers.

Scientific Talent and Critical Thinking Skills

Improving American competitiveness in a global world is becoming more and more critical. Critical thinking abilities seemed to have a significant role in developing scientific talent (Fleming, Garcia, & Morning, 1998). Successful and sufficient academic preparation for minority urban students has been historically challenging, and continues to be challenging for educators in K-12 and higher education environments (Donawa 2009). Many urban public school systems, plagued with a curriculum, focused on rote learning of "basic" skills, opposed to focusing on "problem-solving, thoughtful examination of serious texts and ideas, or assignments requiring frequent and extended writing" (Darling-Hammond, 2000, p. 266). Students who were taught using this pedagogy are at a growing disadvantage when they take standardized tests that focus more on higher order skills, problem solving, and analytic reading and writing ability[20, 21] (Jackson, 1995; Merrow, 2001).

To address the issue of there being a shortage of minority students entering into and successfully matriculating through engineering programs, exploratory studies have been conducted examining the critical thinking skills of minority engineering students (Fleming, Garcia, & Morning, 1995; Fleming & Morning, 1998). In assessing minority engineering students' critical thinking skills, Fleming, Garcia, and Morning (1995) argued that using multiple choice critical thinking assessments were limiting because they were respondent rather than operant measures. In their research, they discovered after giving students from a sample of eight colleges several tests, there were three measures that were found to routinely increase from freshman to senior year: the ability to make comparison analyses; the ability to argue with integrity both sides of an issue; and the ability to think in causal ways. The quality of instruction was associated with degree of change (Fleming, Garcia, & Morning, 1995).

Through a NASA-sponsored program called Project Reserve, a two year initiative, the authors Fleming, Garcia, and Morning (1995) studied 31 correlates, such as social class, aptitude, and critical thinking skills. They used three instruments, with a sample of African American and Latino students majoring in engineering at Xavier University in Louisiana, California State University, Northridge (CSUN), and City College of New York (CCNY). These students (N=79) came from predominantly White engineering schools where they failed in their first year and were invited to participate in Project Reserve. Project Reserve was designed to retain these students in the engineering pipeline by providing them with academic and institutional support (Fleming, Garcia, & Morning, 1995; Fleming & Morning, 1998).

Project Reserve's larger goal was to address the 70% national dropout rate among minority students in engineering programs, in comparison to 50% dropout rate for majority students. The dropout rate seemed connected to minority students not receiving institutional support (Fleming, Garcia, & Morning, 1995). Prior research indicated that producing equitable retention results for minority students required three elements: providing activities that aimed at increasing cognitive abilities; providing activities that established close relationships between faculty and students; and encouraging activities that foster a sense of community and institutional bonding (Fleming, Garcia, & Morning, 1995).

Through their research, they discovered that minority engineering students who pursued careers in engineering disciplines were the best and brightest. Their lack of success at predominantly White institutions may not be indicative of poor academic preparation, but perhaps due to poor institutional and faculty support (Fleming, Garcia, & Morning, 1995). At predominantly White universities, the higher the minority students' critical thinking skills, the less support was given by faculty members. Interestingly enough, emphasis on cognitive development was more apparent at Xavier University, an HBCU, where participating students experienced higher scores and more positive experiences.

In another engineering study at Memphis State University, Drouin (1992) suggested that undergraduate engineering programs have been criticized for not producing engineers who can think critically[23]. Rote memorization, perhaps useful in some educational environments, can be harmful in many work environments, particularly technical fields where skills such as understanding, comprehension, and application are critical to the success of the organization (Drouin, 1992). Unfortunately, the lecture-homework routine in an engineering curriculum leaves little to no time for reflection, critical and creative thinking, and association.

While the results from Fowler's (2003) study revealed that freshmen engineering students have a deep approach to learning when they begin college, their deep approach to learning decreased during the first and second semesters of their freshmen year[24]. Results from the learning strategies intervention suggested that freshmen engineering students do not have the intense learning strategies that are expected and required from engineering students since engineering curricula primarily consist of students being able to apply models and theories (Fowler, 2003). Moreover, Fowler discovered that having a deep approach towards learning had a positive impact on student retention in engineering programs. However, it remains to be addressed as to the impact of critical thinking among African American engineering students.

When examining minority engineering students who attend HBCUs, explanatory research was not found regarding the relationship between critical thinking skills abilities and critical thinking skill development. Teaching critical thinking skills, especially in higher education, seems to have received limited attention when it specifically applies to minority students[25] (Legare, 2002). Zeroing in on building academic skills with the African American population, especially in STEM disciplines, can provide a building block for development and training of such populations. Academic preparation for minority urban students continues to be challenging for educators in K-12 and also by implication for higher education environments.

Problem Statement

This study sought to examine critical thinking levels of African American students before and after their exposure to critical thinking intervention and posed the following question: How does critical thinking intervention affect critical thinking in a university setting? This study sought to examine the impact of a critical thinking intervention on African American students' critical thinking skills for a three-year period. All the students were enrolled in a Historically Black College and University (HBCU) in the Eastern United States.

Consequently, academic under preparation for a higher education environment may present problems for minority students as they pursue undergraduate and graduate degrees, especially in STEM disciplines. The researcher has deliberately used the concept under preparation and not underachievement because she is acknowledging that students have not been exposed, for this case, to a critical thinking methodology.

Conceptual Framework

Paul and Elder (2003, p.11) from their institute, The Foundation on Critical Thinking, suggested that thinking within any discipline "generates purposes; raises questions; uses information; utilizes concepts; makes inferences; makes assumptions; generates implications; and embodies a point of view." [26] In determining a theoretical framework, Paul and Elder's *Elements of Thought*, a critical thinking model, was presented as the foundation for the critical thinking course. The foundational basis for this model supports that "all thinking is purposeful; thinking is done within a point of view regarding an issue; assumptions are made about an issue; implications are made based on the author's reasoning; information and data are gathered and used to support the author's reasoning; inferences, judgments, and conclusions are made based on the information gathered; the inferences are based on concepts and theories to respond to a question or to solve a problem" (Paul & Elder, 2003, p. 3). The researcher introduced students to the *Elements of Thought* Model, and demonstrated how to apply the *Elements of Thought* Model. Students reviewed, discussed, and summarized STEM-related reading materials in a classroom environment. Figure 1 outlines the *Elements of Thought* model and provides a definition for each category. The sub-skills have been added to convey the relationship between The Cornell Critical Thinking Test and the *Elements of Thought* Model.

Elements of Thought Model

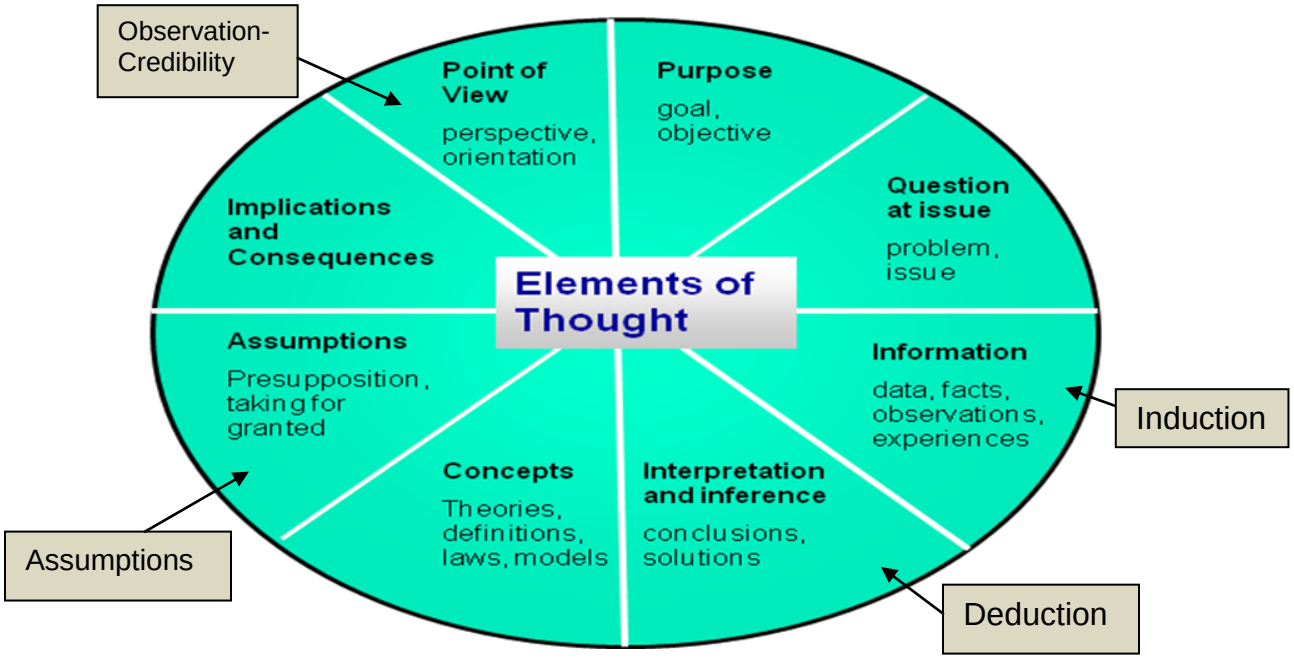

Figure 1

Source: *Elements of Thought* (Paul & Elder, 2003) and Donawa (2009)

Prior to the intervention and the introduction of the *Elements of Thought* Model, the researcher assessed the students' critical thinking levels by using a standardized critical thinking assessment. The Cornell Critical Thinking Test Level X was selected because the critical thinking sub-skills the test measured were more closely aligned to the *Elements of Thought* Model. The four critical thinking sub-skills: Induction, Deduction, Observation-Credibility, and Assumptions that The Cornell Critical Thinking Test Level X examines are embedded within the *Elements of Thought* Model. Induction involves making generalizations based upon observations and experiences[27] (Ennis, Millman, & Tomko, 2005). Observations, experiences, data and facts were found in the Information category of the *Elements of Thought*. Deduction requires conclusions to be made from information provided in any given text[28] (Watson & Glaser, 1980). Deduction is a critical thinking process which involves making inferences and interpretations, which lead to conclusions and solutions, as outlined in the *Elements of Thought* (Paul & Elder, 2003). The critical thinking skill, Observation-Credibility, involves employing contextual clues to make assumptions about a situation and to determine whether the source of information is a primary or secondary source (Ennis, Millman, & Tomko, 2005). Observation-Credibility is found in the *Elements of Thought* Model where the point of view, frame of reference, perspective

and orientation are considered. Finally, the Assumptions sub-skill that The Cornell Critical Thinking Test examines requires a determination of unstated postulations or assertions (Watson & Glaser, 1980). Making assumptions help to fill in gaps in the reasoning process (Ennis et al., 2005). The *Elements of Thought* also includes an Assumptions category where presuppositions are considered.

Enhancing Critical Thinking Skills

Tsui (2003) suggests that all higher educational institutions should enhance critical thinking skill development to their students and should be held accountable to providing this service. Tsui discovered that students entered selective and nonselective higher education institutions with varying levels of critical thinking skills, which widened during the college years. Presumably, those students at nonselective institutions possessed weaker critical thinking skills and were in need of greater improvement than those at selective institutions. There was a great urgency for nonselective higher education institutions to pursue critical thinking skill development. Tsui (2003) questioned that if these students were not provided critical thinking skill development during the last phase of their formal education, then when were they going to receive this service?

Findings from a 1995 follow-up survey from the Cooperative Institutional Research Program (CIRP) revealed that the ability to think critically was rated as the second most important life skill by individuals who had been freshmen nine years before 1995. When rating the importance of critical thinking by education level, income, and occupation, additional data showed that people in high-status occupations, earning higher incomes with more education, judged the ability to think critically more important than those people in low-status occupations, earning lesser incomes, with less education (Tsui, 2003).

As a result of 20 years of research focused on the impact of college on students, Pascarella and Terenzini's (1991) found that institutional selectivity may have trivial impacts on the gains of individual students' cognitive development[29]. Instead, programmatic initiatives and teaching quality seem to have more of an impact on student learning and cognitive growth and development. They did not however study the impact of particular learning programs on students.

Faculty classroom behaviors within higher educational institutions can be linked to student departure[30] (Braxton, Milem, and Sullivan, 2000). Tinto (1993) discovered that there was a problem with student departure at higher education institutions since two-year colleges lose almost half of its students and four-year institutions lose about one-fourth of its students at the end of their first year [31]. Active learning, which included activities such as class discussion, debates, questions asked by faculty, role playing, cooperative learning, and course examination questions, can enhance student knowledge, comprehension, and retention of course content. In fact, students who were engaged in frequent active learning activities perceived gains in knowledge and understand and were more likely to persist in matriculating through an undergraduate curriculum because they viewed their collegiate experience to be personally rewarding. When active learning activities are employed, students had to use a deep level

approach when learning course content, which resulted in students using higher order thinking skills.

Researchers reported using numerous methods to enhance students' critical thinking skills. This researcher included some of the strategies learned from her literature review in her intervention classes. I included class discussions, debates, role plays, and collaborative learning. Each time I introduced a new critical thinking methodology, I had the students apply the concept in class.

Summary of Critical Thinking Pedagogy

Pedagogy	Researcher(s)
1. In-class active learning exercises	Tsui, (1998, 1999)
2. Class discussions, debates, role plays, collaborative learning	Braxton, Milem, & Sullivan, (2000); Paul & Elder, (2002, 2006); Tsui, 1998, 1999)
3. Synthesizing chapters and articles	Paul & Elder, (2003, 2004)
4. Paraphrasing real-time	Paul & Elder, (2003, 2004, 2005, 2006)
5. State, Elaborate, Explicate, and Illustrate (SEEI) model	Paul & Elder, (2002, 2004)
6. Frequent interaction with faculty	Braxton, Milem, & Sullivan; (2000); Gellin, (2003); Tsui, (1998)
7. Out of class experiences, involvement in clubs, and social activities	Gellin, (2003)
8. Peer-reviewed papers	Tsui, (1998, 1999)
9. Self-reflection and assessment	Fowler, (2003)
10. Apply deep approach to learning	Fowler, (2003); Lee, (2004)
11. Practice solving ill-structured, open-ended problems with unlimited solutions	Fowler, (2003); Lee, (2004)
12. Teacher/Professor preparation	Jackson, (1995); Paul & Elder, (2003, 2004); Tsui, (1998, 1999)
13. Practical application so knowledge construction occurs individually	Gordon & Brown, (2004)
14. Help students connect and find meaning enables them to retain information	Diamond, (1998)
15. Frequent writing assignments, thoughtful examination	Darling-Hammond, (2000)

Methodology

In 2006, the researcher used the Watson Glaser Critical Thinking assessment and compared it to Bloom's Taxonomy (Donawa, 2007). As a result of attending a week-long critical thinking workshop sponsored by the Foundation on Critical Thinking in Berkeley, California, the researcher used Paul and Elder's *Elements of Thought* critical thinking model, in addition to the Cornell Critical Thinking Test as the standardized critical assessment. The *Elements of Thought* critical thinking model seemed comprehensive and more aligned with the critical thinking sub-skills that the Cornell Critical Thinking test assessed.

The mixed methods research study asked the question: How does critical thinking intervention affect critical thinking in a university setting? The researcher compared critical thinking test scores between an experimental and control group. To enrich the research design, qualitative data were also included. Students completed written narrative statements about their perceptions of the concepts learned during the critical thinking course and how they might apply those concepts to everyday life. Interviews were conducted with engineering faculty to gain insight to their understanding of critical thinking.

Pre-freshmen engineering students were taught critical thinking methodologies in 2006 and 2007, and were part of the experimental group, Group A. In 2008, students in the pre-freshmen engineering program did not receive the critical thinking intervention, and therefore were part of the control group, Group B. Group A consisted of 50 students while Group B had a total of 40 students participate in the study. The total number of students participating in the study was 90, which provided an adequate sample of students out of the 500 students enrolled in Engineering at Morgan State University. Qualitative data were gathered from participants in Group A since they were part of the experimental group who participated in the critical thinking intervention.

The Cornell Critical Thinking Test Level X was designed by Ennis, Millman, and Tomko (2005). The authors claimed the standardized test was a part of a continuing critical thinking research initiative based on testing, conceptualizing, instructing and developing curricula. In their approach, they identified three types of inferences to beliefs: induction, deduction and value judging. Four types of foundations for these inferences were: a) results of other inferences, b) making assumptions, c) observations, and d) credibility, involving evaluating statements made by others. Not included on the tests were political, economic, and social value judgment questions (Donawa, 2009).

Test users are given specific instructions as to how to respond to seventy-one test items. The answers to five of the test items are given as an example to demonstrate to users how to respond to test items in each section. As a result of the exam being scenario-based, students read commentary and responded to the scene described in the test. The following excerpt was taken verbatim from the Level X test and demonstrates each of the critical thinking concepts.

Exploring in Nicoma

"The year is 2052. It is the middle of June. Imagine yourself to be in the second group from Earth to land on the newly discovered planet Nicoma. Nothing has been heard from the first group, which landed on Nicoma two years earlier. Your group has been sent to make a report about what happened to the first group" (Ennis et al., 2005 p. ii). Then the student is told, " . . . you will be given problems that call for clear thinking. Answer these problems as if the things you are told are true" (p. ii).

The critical thinking test is divided into four sections, assessing the four sub-skills: Induction, Deduction, Observation-Credibility, and Assumptions. The students are expected to respond to questions focusing on what happened to the first group. The scenario-based assessment gets difficult and more complex as the test takers progress through each section.

Research Questions

Four research questions guided the quantitative component of the initial study. However, for this publication, two research questions will be discussed. Inferential statistics such as t-tests of independent samples and t-tests of paired samples were used to analyze the data and discuss the findings. The research questions and the significant findings follow.

Question 1: Were there significant differences in post-test scores for Induction, Deduction, Observation-Credibility, and Assumptions sub-skill sets of a standardized critical thinking assessment for Group A and Group B?

Question 2: Was there significant difference in pre- and post-test scores for Induction, Deduction, Observation-Credibility, and Assumptions sub-skill sets of a standardized critical thinking assessment for Group A?

The qualitative section of the study comprised of two questions for the written student narratives: a) What did I learn today? and b) How can I apply this information? The guiding questions for the engineering faculty were: a) How do engineering faculty members express their understanding of critical thinking methodologies? and b) How do those methodologies impact African American students' critical thinking skills? The following discussion focuses on significant differences found in three of the four sub-skills in the quantitative component of the study.

Findings

Using the Statistical Package for the Social Sciences (SPSS) version 15, the researcher analyzed the descriptive and inferential statistics. The t-test of independent samples was used to analyze statistical differences between Group A and Group B for post-test scores. Overall, the mean post-test scores for Group A, the experimental group who received the critical thinking intervention, were higher than the mean post-test scores for Group B. Moreover, significant differences were found in the Observation-Credibility sub-skill , (t = 4.159, p = 0.000). Group A

mean post-test scores were higher in each sub-skill except for the Assumptions sub-skill. Surprisingly, Group B mean post-test scores were slightly higher.

Summary of Post-Test Results for Group A and Group B

Sub-skill	Group A Mean	Group B Mean	Mean Diff	*T*	Sig	Significance Level
Induction	15.96	14.92	1.039	1.434	.155	>.05
Deduction	13.74	13.71	.129	.158	.875	>.05
Observation-Credibility	14.46	11.66	2.802	4.159	0.000	<.05
Assumptions	5.12	5.45	-.325	-.762	.448	>.05

The researcher conducted a t-test of paired samples quantitative data analyses to compare pre- and post-test scores for Group A, the experimental group. Significant differences were found in the mean difference for the Induction sub-skill when pre- and post-test scores were compared for Group A.

Summary of Pre- and Post-Test Comparison for Group A

Sub-skill	Pre –Test Mean	Post–Test Mean	Mean Diff	*T*	Sig	Significance Level
Induction	15.96	16.96	1.000	2.134	.038	<.05
Deduction	13.74	13.84	-.100	-.241	.811	>.05
Observation-Credibility	13.44	13.25	0.19	.694	.490	>.05
Assumptions	5.10	5.12	-.020	.083	.934	>.05

Results from the Qualitative Research

Students' Narratives

Qualitative data were gathered to understand student perception, comprehension and application of critical thinking methodologies. Student narratives were collected from two qualitative questions that were given to students at the end of each intervention class: a) What did I learn? and b) How can I apply this information? The researcher read students' responses to the two questions; typed their responses into a table that she created in Word; tabulated the frequency of concepts learned and the application of the critical thinking methods; and identified codes and themes based on the responses. Manifest coding was employed to investigate and analyze students' written narratives.

I observed that students' written narrative comments were similar to the verbal comments that students made during the intervention. Prior to giving students some definitions of critical thinking in the intervention class, I accessed the students' prior knowledge and solicited responses from them to inquire about how they would define critical thinking. The majority of the students defined critical thinking as thinking outside of the box.

Regarding their written responses, some students were expressive and wrote detailed information, while others quickly summarized their thoughts into one-sentence responses. Student 5 described what he learned in detail. "I learned some the attributes of a critical thinker, which are, ask pertinent questions and admit lack of understanding or information . . . (I) learned the components of critical thinking, which are identifying and challenging assumptions, recognizing the importance of context, imagining and explaining alternatives, and developing reflective skepticism." Student 18 summarized what he learned in one short sentence, "I learned about the different strategies and critical thinking." From students' responses it can be said that students gained insight about critical thinking, and their responses reflected the depth of understanding of the concepts. The students self-reported five concepts that they learned as a result of the critical thinking intervention, which are identified below.

Comparison of 2006 and 2007 PACE comments to What did I learn today?

Concepts Learned	2006 PACE (N=37)	2007 PACE (N=30)
1. Definitions of Critical Thinking	35%	63%
2. Bloom's Taxonomy	43%	97%
3. Attributes of Critical Thinkers Learning	59%	53%
Additional Critical Thinking Taxonomies		
4. Critical Reading and Writing Strategies	54%	74%

5. Self-Assessment of Own Learning	46%	13%

Students' included higher level comments in the second question pertaining to how they would apply the information learned from the critical thinking intervention class. Student 48 wrote a rather long descriptive and informative narrative when explaining how he could use the concepts learned, "This information can be applied when testing. Some of the words can help me to know which taxonomy it is talking about. During my first semester at Morgan, I can use the traits that I learned to help me in class. Being an active reader in college is very important and depending on how well I can do in a class. I can use this concept when I try to think critically on any given situation." When responding to the same question as to how I can apply this information, Student 50 wrote, "I can use this information to answer test questions better. I can also answer questions asked orally to me in a smarter fashion. I can use the acronyms to pass my test."

Comparison of 2006 and 2007 PACE Comments to How can I apply this information?

Application of Information	2006 PACE (N=37)	2007 PACE (N=30)
1. Reflective thinking; deeper understanding	43%	80%
2. Problem-solving; asking questions; integrate critical thinking in research	27%	60%
3. Become a critical thinker	19%	1%
4. Critical reading and writing strategies used on tests and exams	46%	73%
5. Everyday skill and collaborative learning	22%	40%

My research findings based on the student narratives support the claim regarding students' cognitive development being enhanced by critical thinking methodology. Students reported being aware of thinking about their thinking, metacognition, the importance of inquiry, and understanding the integration of critical thinking into their course work and everyday lives.

Findings from Faculty Interviews

Two qualitative exploratory questions guided the interviews with two Engineering faculty, although additional questions were used during the actual interviews: How do engineering faculty members express their understanding of critical thinking methodologies? and

What are faculty perceptions of those methodologies impact African American students' critical thinking skills?

Interviews were conducted with two faculty members in the fall 2006 semester. The professors did not want their real names to be used and preferred anonymity. Therefore, in the study, the female assistance professor will be referred to as Dr. Jane, and the male assistant professor will be referred to as Dr. Smith. Both assistant professors teach within the School of Engineering at Morgan State University, in Baltimore, Maryland. Interviews and observation notes were taken. Interviews were recorded on a digital audio recorder. The researcher of this study previously worked with the two faculty members at Morgan State University.

During the fall 2006, I was able to observe Dr. Smith teaching two of his engineering classes. I gave him suggestions and recommendations, such as the use of Socratic Questioning techniques when asking students questions. I also revised tests and quizzes to include questions that required students to explain in detail their methods and logic for solving problems and equations. During conversations with Dr. Smith, I shared materials and information about the Foundation on Critical Thinking's Intellectual Standards. Questions for Dr. Smith were based on his thoughts about critical thinking; integrating critical thinking into an engineering curriculum; a brief comparison between students attending HBCU's and majority schools; and his perceived changes in his teaching style.

Asking more questions in class transformed Dr. Smith's class from being passive to active. "It [critical thinking] has changed it [my teaching style] quite a deal because I ask more questions, instead of . . . solving the problems or going through the theory on the board, I put more problems on the board, and I ask the students to go through the problems. And that enables them to think about the problem and to come up with solutions to solve the problem. So it has taken my class from a passive class into a more active class. And a lot of students tend to like it because they are more involved instead of just sitting there taking notes."

Responses from Drs. Jane and Smith were similar when asked the importance of engineering students having good critical thinking skills. They agreed that part of being an engineer was to solve problems creatively. Dr. Jane stated, ". . . And in solving problems, a student needs to be aware or have an approach to solving problems and, developing good critical thinking skills will allow them to develop a process by which they can solve problems effectively or efficiently." Dr. Smith suggested, "As an engineer, fundamentally they should be able to solve problems. Critical thinking is a major component for them to be able to solve problems, and it is vital; and critical thinking should be included in all the programs."

The link to critical thinking was made through Dr. Jane's expectations of the students asking her several questions for clarity and understanding. "Another thing that I am looking for is how do they think . . . at this stage, I do expect them to come to me with a lot of questions, so to me that is expected. But I am also looking at the types of questions that they are asking me, meaning do they come to me with something already done and they ask me a question, or are they asking me a question and they don't have anything done."

Latent coding was employed for the faculty interviews because the researcher looked for meaning from the context of the interviews. The following themes and categories were derived from the engineering faculty interviews.

1. Attributes of Engineers
    a. Creative problem solvers and the need for higher level of thinking.
    b. Ability to work in teams and independently.
    c. Ability to ask thought provoking questions.
2. Critical Thinking
    a. Imperative to integrate into math, science, and engineering.
    b. Linked to reading and comprehension skills.
    c. Changed class from being passive to active.

Implications and Recommendations

The study examined whether a critical thinking intervention taught at a Historically Black College and University (HBCU) would increase students' critical thinking skills. Both quantitative and qualitative data were gathered. Quantitative data were gathered from Group A, the experimental group and Group B, the control group using The Cornell Critical Thinking Assessment Level X, a standardized critical thinking assessment.

Qualitative data were gathered also from student narratives and faculty interviews. The researcher discovered the qualitative portion of the study brought greater clarity and insight to the research problem. The narratives from participants gave insight to student perspectives on critical thinking pedagogy and the application of critical thinking in the lives of engineering undergraduate students. Moreover, the qualitative data gathered would increase the researcher's understanding of the intervention beyond the quantitative numbers gathered. Interviews with engineering faculty members enabled the researcher to determine faculty perceptions regarding the importance of critical thinking and having this methodology integrated into an engineering curriculum. Engineering faculty also addressed the impact of critical thinking on African American students' critical thinking skills.

Employing critical thinking pedagogy could explain why the post-test scores were higher than the pre-test scores in some of the sub-skills. Participants in Group A were taught how to analyze quotes and reading passages; and then practice making generalizations and summarizing reading passages using their own words to present to the students in the critical thinking intervention class. Students enjoyed working in small groups and reporting their findings to the whole group. Individual work was peer-reviewed in the small group. Student participants helped to establish the rubrics for evaluating the group presentations. When we developed rubrics for grading their team presentations, it was surprising to observe the students graded each team more harshly than I would have. As a result of having the class responsible for grading

each team, the students were more interested in the content. They listened attentively and asked meaningful questions.

The pedagogical techniques implemented in the critical thinking intervention supported research in enhancing students' critical thinking skills. Data analyses from a national sample of college students found that self-assessed growth in critical thinking was related to instructional factors such as having a paper critiqued by an instructor; conducting independent research; working on a group project; giving a class presentation; and taking an essay exam (Braxton, Milem, & Sullivan, 2000; Paul & Elder, 2002, 2006; Tsui, 1998, 1999) [32].

As the facilitator of the critical thinking intervention, when students asked questions, I used the Socratic Questioning technique by re-directing the questions to the students. Throughout the critical thinking intervention, I constantly asked questions to check for student understanding and comprehension, in addition to having the students paraphrase in their own words comments and responses given by others. Opportunities were given for class debates and ample time was allotted for student responses. Quizzes and tests were given weekly on the topics covered in the intervention class. However, as Drouin (1992) noted, the lecture-homework routine in an engineering curriculum leaves little to no time for reflection, critical and creative thinking, and association.

As a researcher, I found my role to be a revealing one. Not only did I come to understand better the importance of doing both quantitative and qualitative research simultaneously, but also I found the rich voice of the study from the student narratives and the faculty interviews. This voice proved critical to the research as it helped to describe the importance of the human element combined with the quantitative element. My role as the interventionist seemed to be verified.

The findings from the study support a similar study assessing students' critical thinking skill levels. Drouin (1992) discovered significant differences in overall critical thinking ability between sophomores and seniors in engineering disciplines at Memphis State University. Students in their senior year scored higher in deductive reasoning and inference skills than the sophomores. Based on these findings, it can be assumed that students' induction and inference skills will increase over time as they continue their academic careers in a higher education institution.

I discovered from my research study that students were thoughtful and reflective when making observations about the concepts they learned during the intervention. Student 49 commented on the critical thinking strategies learned, "This is beneficial because this can help me to change the way I study." Student 52 observed, "Every time I read something, I can use the *Elements of Thought* to better understand the work." Induction includes the process of gathering data and facts; one way to gather data and facts is to ask questions. Dr. Jane verified that asking questions was pertinent to the learning process, "I do expect them [the students] to come to me with a lot of questions, so to me that is expected." Moreover, Dr. Smith confirmed that asking questions, "…enabled them to think about the problem and to come up with solutions to solve the problem."

Exposing students to critical thinking skills may have a positive impact on African American students obtaining degrees from higher education institutions. As The American Society for Engineering Education reported in "Profiles of Engineering and Engineering Technology Colleges (2008) publication, African Americans were earning degrees at a much slower rate than their Caucasian counterparts. In fact, their research reported the more advanced the degree, the lower the percentage rate was for African Americans to obtain an advanced degree.

If class origin, race, and socio-economic levels may indeed determine the academic success in America, then teaching African American students critical thinking skills explicitly may be one method to employ to address the disparity issue[32] (Fisher, 2001; Schorr, 2002; Tsui, 2003). Instruction in critical thinking could prepare African American students to be academically successful in higher education institutions, and provide them with opportunities to major in STEM disciplines.

Research by Stark and Lattuca (1997) reveals that faculty incorporates instructional processes into academic curricula based on their knowledge and experience. Faculty awareness of critical thinking pedagogies and their positive impact on students' critical thinking skills can help fuse critical thinking into academic content. Moreover, faculty classroom behaviors can impact students' academic success[33] (Braxton, Milem, & Sullivan, 2000; Fleming, Garcia, & Morning, 1995; Tatum, 2007).

Differences in Group A and Group B's mean scores on the Cornell Critical Thinking Test Level X suggest that faculty should work together to ensure the development of critical thinking skills. Critical thinking is a non-unidimensional concept that has an interdependent relationship with induction, deduction, observation and credibility, and the ability to make assumptions, which causes an overlap of these skill sets in the actual critical thinking process (Ennis, et al., 2005).

While the results from the quantitative and qualitative results demonstrate students are bringing some level of critical thinking skills to the higher education environment, it is evident that there is a need for greater intervention. The role of higher education is to cultivate students' critical thinking skills levels (Dubuc, 1999; Tsui, 2003). Faculty awareness of the study's findings can initiate dialogue regarding ways to enhance students' critical thinking skills at Morgan State University.

If external government agencies such as the National Science Foundation (NSF) and the National Aeronautics and Space Administration (NASA) shared common observations about educational disparities in science, technology, engineering, and mathematics (STEM) disciplines as it relate to African American students, then institutions of higher education, particular HBCUs, may consider developing and cultivating students' critical thinking skills as a high priority that may be addressed in a strategic or academic plan, or integrated into institutional policies and procedures.

Summary

Critical thinking is a term that continues to manifest itself in many classrooms around the globe. While many institutional leaders are concerned about enhancing student learning outcomes, they also recognize the fundamental issues impacting this development. Faculty are urged to play a pertinent role in incorporating critical thinking sub-skills: Induction, Deduction, Observation-Credibility and Assumptions. When students are actively engaged in continuous learning activities, they model a deep approach towards learning course content, and as a result, they apply critical thinking skills (Braxton, Milem, & Sullivan, 2000; Fowler, 2003; Tsui, 1998, 1999, 2003).

Administrators and other higher education stakeholders should work towards developing and enhancing non-academic programs such as social activities that promote critical thinking skills. Moreover, research shows that participation in social events and out of class activities help students develop critical thinking skills[34] (Gellin, 2003).

The results from the study will be given to faculty within STEM programs at Morgan State University, and faculty within other disciplines and administrators across campus to establish on-going dialogue and communication to determine the best approach to integrating critical thinking into curricula. Classrooms could be transformed from primarily being instructor-led to a facilitation-style approach where professors are more engaging, allowing time for inquiry where students can ask questions, take risks, and be more confident in problem-solving in a flexible and adaptable classroom.

The results of the study were anticipated to be of particular interest to engineering faculty members at HBCUs and to other faculty members within all academic disciplines at various public and private higher education institutions. Faculty can receive insight regarding students' current levels of critical thinking pertaining to Induction, Deduction, Observation-Credibility, and Assumptions sub-skill sets, enabling determination of students' academic profiles prior to their enrollment into a formal college environment.

Furthermore, having an academic profile that includes critical thinking skills levels could help faculty determine an appropriate academic plan for students could assist with academic advising. The quantitative and qualitative research questions utilized in this study guided the presentation of conclusions, implications, recommendations for policies and practices, and recommendations for further research.

The study may contribute to the literature on critical thinking among African American students at HBCUs. Research on critical thinking skills and African American engineering students attending an HBCU were limiting (Legare, 2002). Further research on this population pertaining to critical thinking skills could continue to add to the body of knowledge.

References:

[1]Tsui, L. (2003). *Reproducing social inequalities through higher education: Critical thinking as valued capital.* The Journal of Negro. Education, *72*(3), 318-332.

[2]Tsui, L. (1998). *A review of research on critical thinking*. 1998 ASHE. National Conference. CA: University of California.

[3]Tsui, L. (1999). *Critical thinking inside college classrooms: Evidence from four institutional case studies*. 1999 ASHE National Conference. San Antonio, TX.

[4]Darling-Hammond, L. (2000). New standards and old inequalities: School reform and the education of African American students. The Journal of Negro Education, *69* (4) pp.263-287.

[5]Dubuc, P.A. (2000). *Disciplinary differences in students' approaches to the learning task*. Proquest Information and Learning Company. MI: Ann Arbor. Retrieved on February 25,

[6]Donawa, A.M. (2009). *Critical thinking instruction and minority engineering students at a public urban higher education institution*. Proquest Information and Learning Company. MI: Ann Arbor. Retrieved on December 19, 2010

[7]Jibrell, S. B. (1990). *Business/education partnerships: Pathways to success for black students in science and mathematics*. *The Journal of Negro Education, 59*(3), 491-506.

[8]Schorr, J. (2002). *Hard lessons: The promise of an inner city charter school*. NY: The Ballantine Publishing Book.

[9]National Science Foundation Science (2007). *Engineering degrees by race and ethnicity of recipients 1995-2004* http://www.nsf.gov/statistics/nsf07308/pdf/nsf07308.pdf, Retrieved on January 31, 2007.

[10]The American Society for Engineering Educationional (2008). Profiles of Engineering and Engineering Technology Colleges.

[11] Fleming, J., Garcia, N., and Morning, C. (1995). The critical thinking skills of minority engineering students: An exploratory study. The Journal of Negro Education, 64. *4*. pp. 437-453.

[12] Fleming, J., Garcia, N., and Morning, C. (1998). *Correlates of the SAT in minority engineering students: An exploratory study. The Journal of Negro Education, 69(1),* 89-108.

[13] McDonald, L. & Powell, J. A. 1998. *The rights of racial minorities: American Civil Liberties Union handbooks for young Americans*. NY: Puffin Books.

[14] Lee, M. W. (1986). *The match: Learning styles of black children and microcomputer programming*. The Journal of Negro Education, *55* (1), 78-90.

[15] Garibaldi, A. M. (1997). *Four decades of progress…and decline: An assessment of African American educational attainment. The Journal of Negro Education*, *66*(2), 105-120.

[15] Garibaldi, A. M. (1997). *Four decades of progress…and decline: An assessment of African American educational attainment. The Journal of Negro Education*, *66*(2), 105-120.

[16]Cohen, A. M. (1998). *The shaping of American higher education: Emergence and growth of the contemporary system.* CA: Jossey-Bass Publishers.

[17]Donawa, A. M., Martin, C., Taylor, K.J., White, C. (2007). *Re-engineering engineering: Teaching students how to think critically.* ASEE Conference. Honolulu, HI.

[18]Gordon, A. & Browne, K. (2004). *Beginnings & beyond: Foundation in early childhood education.* NY: Delmar Learning.

[19] Stark, J.S. & Lattuca, L.R. (1997). *Shaping the college curriculum: Academic plans in action. MA: Allyson and Bacon.*

[20] Jackson, M.W. (1995). Skimming the surface or going deep? Political Science and Politics, *28*(3), 512-514.

[21]Merrow, J. (2001). Undermining standards. Phi Delta Kappan. 653-659.

[22]Drouin, L.E. (1992). *An investigation of the critical thinking ability of students seeking a Bachelor of Science degree in various engineering associated disciplines*. Ann Arbor, MI: Proquest Information and Learning Company. Retrieved on March 14, 2007.

[23]Fowler, D.A. (2003). *Defining and determining the impact of freshman engineering students' approach to learning.* Ann Arbor, MI: Proquest Information and Learning Company. Retrieved on February 25, 2005.

[24]Legare, G. (2002). *An investigation of the effect of task design on the development of critical thinking skills by engineering students.* Ann Arbor, MI: Proquest Information and Learning Company. Retrieved on February 25, 2005.

[25]Paul, R. & Elder, L. (2003). *How to study and learn: A discipline using critical thinking concepts and tools.* Berkeley, CA: The Foundation for Critical Thinking.

[26]Ennis, R.H., Millman, J., Tomko, T.N., (2005). *Manual for the Cornell Critical Thinking Tests, Levels X and Z.* Pacific Grove, CA: Midwest Publications.

[27]Watson, G. & Glaser, E.M. (1980). *Watson-Glaser Critical Thinking Appraisal*.

[28]Pascarella, E. & Terenzini, P. (1991). *How college affects students: Findings and insights from twenty years of research.* San Francisc: Jossey-Bass.

[29]Braxton, J.M.., Milem, J.F., Sullivan, A.S., (2000). *The influence of active learning on the college student departure process: Toward a revision of Tinto's theory.* The Journal of Higher Education, *71*(5), 569-590.

[30]Tinto, V. (1993). *Leaving College: Rethinking the causes and cures of student attrition.* (2nd ed.) Chicago: University of Chicago Press.

[31]Paul, R. & Elder, L. (2006). *Critical thinking: Tools for taking charge of your learning and your life.* (2nd ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

[32]Fisher, A. (2001). *Critial thinking: An introduction.* Cambridge University Press. UK

[33]Tatum, B.D. (2007). *Can we talk about race: And other conversations in an era of school resegregation.* Boston, MA: Beacon Press.

[34]Gellin, A. (2003). *The effect of an undergraduate student involvement on critical thinking: A meta-analysis of the literature 1991-2000. Journal of College Student Developmen*t, *44*(6), 746-762.