Science and Mathematics Education Centre

A Precollege Engineering Program's Effects on the Grade Eight Minority Students' Attitudes and Achievement in Science and Mathematics

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any other person, except where due acknowledgement has been made.

Signature:

Date: 8 April 2009

DEDICATION

In 1957, Aldwyn Brennan Innerarity graduated from Columbia University, in New York, with a degree in Civil Engineering. He was one of eight siblings – four boys and four girls, born to educators. Upon graduating from Columbia, he returned to his home country of Jamaica where he was a successful, practicing engineer for the island's most lucrative export – bauxite. In 1975, he was recruited back to the United States to fill an engineering need, but eventually encountered many of the challenges that most minority males face in this country. It is in his memory that this thesis is dedicated; and to all the other African American and Hispanic males in my family who inspired me to pursue this research topic. I feel as though it was my destiny to become involved in SECME. Special thanks are first and foremost extended to my husband, Simón, who always encouraged and supported my educational and professional pursuits; to my mother, Pat, whose financial support, love, and encouragement made this moment possible – an outstanding role model. To my late grandmother, Mae, who always believed this day would come; to my siblings, Andrew and P.G.; niece – Alexandra; cousins – Adrian, Petes, Soleil, Clem, Clive, Tony; Mark, aunts – Betty, Percy, and Monica; uncles – Al and William; and friends – RBM - your love, inspiration and encouragement have meant the world to me. Alison, you led the way. Uncle Ronnie – I'm a Doc! Thanks. It just got better.

ABSTRACT

The National Science Board has declared that the production of citizens literate in science, technology, engineering and mathematics (STEM) is at an all time low in the United States. Schools are not sufficiently preparing students to enter and complete postsecondary studies in STEM areas to ensure their global competitiveness and place the economy in the stable standing experienced over the decades The U.S. has been known for its innovation; however, in the changing global climate, countries like India and China are out-producing, out-graduating and becoming the technological centres of the 21st Century. Thirty-five years ago, several organizations tried to address similar issues while focusing on minorities. Nevertheless, these efforts had not seemed to take a stronghold in school districts until recently, and even then, the question remains - What impact is the program having on eliminating the achievement gap so that all students are prepared to enter postsecondary studies in STEM?

This research attempts to examine a precollege engineering program's impact on minority students' attitudes and achievement in mathematics and science. The program is called SECME, formerly the Southeastern Consortium for Minorities in Engineering. The study used a research framework for curriculum evaluation to assess the presence and participation of middle school minority students in a precollege engineering program through an analysis of the intent of the program, its implementation and the actual program outcomes. The research incorporated a pre-post design with triangulation of methods through the use of pre- and posttest surveys using the modified Test of Science Related Attitudes (TOSRA) and Test of Mathematics Related Attitudes (TOMRA), researcher-developed questionnaires, and observations. Academic achievement was determined by student performance on the state administered Florida Comprehensive Assessment Test (FCAT).

The setting of the study took place in an urban public school district, the fourth largest in the nation, located in the southeast section of the United States of America (USA). In this district, the minority group actually represented the majority of the district population; a demographic trend that is expected to be realised nationally in the next 50 years. The study took place over a two-year period and only sampled

students from heterogeneously-mixed or co-educational middle school environments. However, due to problems with collecting post-test data, only the second year of the data are reported in this thesis. The participants in this study were from 10 of the 54 middle schools in the district. In-depth case studies were conducted with three of the schools which were purposefully selected for their diverse representations of student populations across the district.

The modified TOSRA and TOMRA were used, along with researcher developed questionnaires, to analyse SECME and non-SECME middle grades students' attitudes towards science and mathematics, respectively. The criterion-referenced test that held schools accountable for instruction, the Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards (SSS), along with the FCAT Norm-Referenced Test (NRT) were used to ascertain and compare student achievement in science and mathematics, respectively. The FCAT SSS assesses the state standards that are expected to be taught in Florida science classrooms, and the FCAT NRT compares Florida students with their peers nationally. An analysis of these data indicated that a comparison in science achievement and attitudes to science between ethnicities for SECME and non-SECME students indicated no significant difference on the subscale posttest attitudinal scores. There were, however, significant differences for the non-SECME students between ethnicities and their scores on the FCAT SSS, in particular between White American and African American and between Others and African American students.

In mathematics, there was a significant difference with respect to the FCAT SSS Mathematics and Achievement Levels, in favour of non-SECME students. Of note, there were no significant differences in the NRT Mathematics percentile and posttest attitudinal scores of the TOMRA for SECME and non-SECME males. This is of particular interest because the NRT compares students nationally as opposed to the FCAT SSS that assesses the student's knowledge solely of the state's curriculum content. Overall analysis, also indicated no statistically significant differences between ethnicities for the SECME students on the TOMRA scales or the Mathematics Achievement tests as opposed to the non-SECME students that demonstrated a statistically significant difference between ethnicities. This finding appears to be an indication that the achievement gap across ethnicities in this sample of SECME students did not exist. Another finding of interest was that Adoption of Scientific Attitude is a significant, independent predictor of FCAT Mathematics Achievement Level, and for SECME students, Enjoyment of Mathematics Lessons correlated positively with FCAT SSS Mathematics scores and FCAT NRT Mathematics percentile scores.

The implementation of the program seems to be addressing the needs of minority participation with respect to Hispanic males, but insufficiently for the African American males and females. This finding was evident with the number of respondents on the surveys and participation in SECME program offerings and in the case studies. Qualitative data revealed that there is a lack of African American male coordinators and role models for the students participating in the SECME program which could result in fewer numbers of these students participating in events. There was also commentary that transportation was an issue for these students which may have contributed to the low participation of these students in Saturday seminars.

A more extensive representation of the SECME program's achieved curriculum would have been better analysed without certain limitations to the study. One such limitation was the fact that the FCAT SSS and NRT for science were only administered in the middle school years during grade 8. This limited the study sample for the quantitative data collection. Additionally, a longitudinal study of these same students as they move through senior high school, college, and eventually careers, should be forefront for further research to assess the efficacy of this and any other precollege engineering program.

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CHAPTER 1

INTRODUCTION

…without scientific literacy and an engineering community, young people cannot dream of "what can be"

(Committee on Science, Engineering, and Public Policy, 2007)

1.0 Overview

In 1944, President Franklin D. Roosevelt looked into public policy related to scientific research and observed "New frontiers are before us, and if they are pioneered with the same vision, boldness and drive with which we have waged this war [World War II], we can create a fuller and more fruitful life" (Committee on Science, Engineering, and Public Policy, 2007, p. 112). In 2008, this predicament has not changed. The Committee on Science, Engineering, and Public Policy (2007) has noted that without scientific literacy and an engineering community, young people cannot dream of "what can be" to address the persistent national problems to include the provision of energy, environmental preservation, and economic growth. Equally imperative is the preparation of the country's minority population whose growth is increasing exponentially and will soon be the majority population; therefore, an eradication of the achievement gap is vital for the survival of the nation. This chapter presents an introduction to the research as it pertains to the presence and persistence of middle grades minority students in a precollege engineering program and their attitudes towards and achievement in mathematics and science. There are eight sections. Section 1.1 establishes the need for precollege engineering programs, Section 1.2 provides the background and rationale for the research, Section 1.3 describes the research design, Section 1.4 illustrates the objectives of the research, Section 1.5 establishes the significance of the research, Section 1.6 defines the scope and limitations, Section 1.7 poses ethical issues, and Section 1.8 provides a summary of the chapter.

1.1 The Need for Pre-college Engineering Programs

The United States of America (USA) is falling behind the rest of the world when it comes to recruiting and producing the workforce needed to fill its job demands in the fields of science, technology, engineering and mathematics – STEM (National Science Board, 2007). Furthermore, minority students are dropping out of college, and for those that are enrolled, engineering and science are not the majors they are pursuing (Bryant, 1993). As an example, the American Dental Education Association (ADEA) indicated that there has been a pervasive shortage of minorities entering the dental field. Through funding from the National Science Foundation and National Institute of Health, over 200 students were engaged in a program to produce PhDs and MD PhDs. Among the factors that influenced the program was the involvement of families and mentors of all races and genders. The ADEA conference (2000) insisted that too few 17 year olds demonstrated strong mathematics skills and although the K-12 achievement gap between minorities narrowed between 1970 and 1980, it was again widening.

To further compound the situation, the increasing globalization and outsourcing to countries that have the personnel to meet the STEM demands will force the USA to address a critical shortage in its local STEM workforce (Friedman, 2005; Honawar, 2005). During the 20th century, America attracted and encouraged foreigners to study in its prestigious postsecondary institutions to fill its workforce demands. According to the National Science Foundation (2002), the science and engineering occupations/opportunities are expected to increase by 47% between 2000 and 2010. Historically, more than one-half of H-1b temporary work visas for foreigners were for computer-related, science and engineering positions (NSF, 2002). However, now that other countries are gaining ground technologically with the USA, moving to America is not as attractive or practical for foreigners (Friedman, 2005). The increased availability of and access to technology has allowed for global communication and connection, allowing professionals to opt for staying in their countries where their families, customs, and cultures remain intact (Friedman, 2005).

1.2 Background and Rationale

The location of this research took place in the southeastern region of the United States. The overall student population demographics of the middle schools in the area were 10% White, 29% Black, 59% Hispanic, and 2% Other - Asian/Indian/Multiracial (Miami-Dade County Public Schools, 2004). Individual neighborhoods throughout the school district, however, did not share this ethnically diverse demographic. Schools, therefore, offered magnet programs to bring a more ethnically/racially diverse population to schools in less racially integrated communities.

> Magnets are curriculum programs of choice. Magnet programs/schools provide elementary, middle, and senior high school students unique learning opportunities. Students who are talented or interested in a particular profession or course of study may apply to a magnet program of their choice. Each magnet program/school requires its students to enroll in the required academic courses as well as electives related to the theme-centered program. Admission requirements vary from program to program. For instance, performing arts require an audition while academic programs may require an interview and teacher recommendation. (Miami-Dade County Public Schools, 2006; p. 51)

In 2008, the Superintendent of Schools announced a proposed plan to provide greater access to magnet schools through the Equity and Access Plan that addressed the presumption that magnet programs had previously been randomly placed across the district; this plan would provide more children with access to high-demand programs, especially minorities and the low socio-economic (McGrory, 2008). At the time of the research, there were 347 public schools, of which, there were 37 high schools, 54 middle schools, 7 K-8 Centers, and 199 elementary schools (Statistical Highlights, 2004). In addition, there were several charter schools established to meet the needs of parents who wanted their children to attend public schools in a smaller, more privatized setting. The area was also home to several institutions of higher learning consisting of a multi-campus community college and research universities. The average median income, according to the Census 2000, was $33, 035 with 19% of the population living below poverty level.

The district had seen a decline in student achievement in mathematics and science during the middle school years. The researcher had also noticed that the representation of minority males in the district's central office science department was underrepresented. However, minority females were more prevalent. There had been tremendous effort and attention to attracting females to STEM for more than a decade, but was this affecting the minority male representation in those same fields? Numerous programs in the District were designed, in general, to target minorities to pursue STEM careers.

Consistent with this effort, the research attempted to answer the question: How does participating in the SECME precollege engineering program affect middle grades students' attitudes and perceptions towards mathematics and science achievement? SECME, Inc. (SECME) is a national strategic alliance that enhances science, mathematics and engineering instruction through extensive professional development of teachers. The national SECME model is described as

> ...grounded in inquiry-based teaching and learning. This investment has brought consistently high returns--improving student outcomes, ensuring post-secondary success, and opening rewarding career opportunities in areas vital to the nation's economic well-being and global success (SECME Corporate and Foundation Statement, 2001).

The SECME program implemented in the school district involved in this research combined the national model of teacher inservice programs, also known as professional development, with a student and parent training model conducted by industry, government, and/or university partners. Through the district program, students were mentored, encouraged to participate in engineering design seminars, and exposed to learning environments of higher education and STEM careers. This research intended to examine whether the program was meeting its intention to improve student outcomes in mathematics and science achievement and what effects this had on participating middle school minority students' attitudes towards and achievement in science and mathematics.

1.3 Research Design

The theoretical framework used to determine the effectiveness of the SECME program compared the ideal or intent of the SECME precollege engineering program design with the experiential aspects of the program (van den Akker, 1994). The framers of SECME established the intent of the program and formal documentation in 1975. The implementation of the program was interpreted by the various school districts and/or participating schools across the nation, whereas, the actual implementation of SECME was contingent on the school-site program coordinator. Therefore, the program experiences that the student enjoyed may or may not be what the framers initially intended with the design. By analysing the various components and implementation of the program, one may determine the efficacy of the SECME program.

1.3.1 The SECME Program Design

The local SECME program consisted of several engaging, hands-on, precollege engineering activities that were intended to be engaging for students, parents, and teachers. Students visited engineering worksites and colleges in order to gain postsecondary experiences. Teachers and administrators were invited to participate in Professional Development seminars addressing minority student motivation in mathematics, science, engineering, and technology. Furthermore, students attended SECME Saturday Engineering Design Seminars presented on college campuses. They were instructed by engineers, college students and faculty on mechanical and civil engineering concepts through model bridge construction, mousetrap car design and the principles of rocketry which allowed participants to design and build projects that were later used in local and national competitions. Although the program's main focus was to target minority students, the school system could not deny program access to any public school student who expressed an interest to participate. Furthermore, as indicated in Section 1.1, African-Americans have become a minority in STEM career representation. Through exposure to college campuses and postsecondary education opportunities in the fields of engineering, the ultimate program goal was to encourage students to pursue studies in STEM and, therefore, increase representation in those career paths.

1.4 Objectives

The purpose of this research was to primarily examine a pre-college engineering program to ascertain its effectiveness in enhancing African American and Hispanic American middle grade students' attitudes and perceptions towards mathematics and science and their subsequent academic achievement in those subjects.

1.4.1 Research questions

The major issue, the examination of a precollege engineering program on the middle school minority students' attitudes towards and achievement in science and mathematics, was addressed in seven research questions:

Research Questions

1. What is the intention of the SECME program?
2. How is the SECME program implemented across the District?
3. What are the reliabilities of the modified scales of the Test of Science Related Attitudes (TOSRA) and the Test of Mathematics Related Attitudes (TOMRA)?
4. What are the changes in SECME and non-SECME students' achievement in science and attitudes towards science following their experiences in a precollege engineering program?
5. What are the changes in SECME and non-SECME students' achievement in mathematics and attitudes towards mathematics following their experiences in a precollege engineering program?
6. What is the relationship between attitudes towards science/mathematics and academic achievement following their experiences in a pre-college engineering program?
7. What are students' parents', teachers' and the researcher's reflections on minorities' achievement in science and mathematics?

1.5 Significance

Bushweller (1997) reiterated the impact of expectations on student performance in an interview with Peter McCabe, administrator in the Office of Policy and Evaluation at the California State Department of Education. McCabe insisted that low expectations of rural and poor inner-city schools could only lead to poor student performance since students strive for what is expected of them. The anticipation of this research was that the SECME program teachers and parents would have high expectations of all students, especially, females, and African American and Hispanic American males, therefore, promoting positive attitudes and encouraging these students to excel in mathematics and science.

Results of this research were significant for systemically delivering a program that encouraged achievement in minorities by sharing the program strategies with teachers, administrators, and parents to model these habits in the classroom and at home. There had been documentation in the Miami-Dade School district that students participating in SECME, on average, performed better on norm and criterion referenced state tests when compared to students not participating in SECME district-wide. There was no research, however, into whether students' attitudes towards mathematics and science were affected by SECME and whether or not their attitudes correlated to their academic achievement in those areas. Additionally, there was no documentation as to whether the program was addressing the needs of the students for whom it was initially intended. By analysing student, teacher and parent comments, a deeper understanding of the aspects of the program that encouraged mathematics and science learning in students would be identified; thus, strengthening the program implementation.

1.6 Scope and Limitation

The SECME program was implemented in a variety of ways in each of the schools. There were no criteria for schools to become involved in SECME other than an indicated interest. The only commonality that the researcher was able to use for certain aspects of data collection was to target those schools that participated in the District sponsored Saturday engineering seminars and the end-of-the-year competition. However, at the school-site, the program was found to be integrated in the daily curriculum activities or delivered to students in a before/after-school session. Since there was no prescribed implementation plan for the schools to follow, this made it difficult to track the successes in a controlled experimental method. Additionally, the school district, although diverse, was not equally distributed racially at each of the schools. In other words, different regions across the district had their own unique demographic distribution.

Identifying student ethnicity also proved to be an interesting challenge. The school district was part of a diverse metropolitan area of the state that described itself as the "gateway to the Americas" which was greatly influenced by the influx of immigrants to the area. Therefore, African American and Hispanic students were classified by ethnicity and not culture, significant data was gathered as to the effect on African and Hispanic heritage students regardless of their cultural background. There were many participating students who often identified themselves as Haitian American instead of African American (AA) and Cuban American instead of Hispanic (H). There will be further discussion on this in Chapter 3. The terms Black and African American are used interchangeably throughout this study, likewise Hispanic and Latino. However, cultural data collected by the researcher were maintained in records for possible extended research.

Data collection also proved to be somewhat limiting and challenging. The student assessment data that was used for comparison were only administered in grade eight for science as opposed to the mathematics assessments that were administered for grades six, seven and eight, each year. This, therefore, limited the sampling of students to grade eight for the attitudinal survey and assessment test correlations. The school District also had certain restrictions on how data could be collected and returned to the researcher, which presented certain obstacles and constraints that required multiple attempts to retrieve the data. This is discussed further in Chapter 3.

1.7 Ethical Issues

The research aims were clearly imparted to all participants and the school system's Office of Educational Planning and Quality Enhancement. Permission to participate was sought from the schools' principals, and since the students were under 18 years of age, parental/guardian permission was also solicited. Privacy and confidentiality of participants were guaranteed in writing. Participants who opted not to participate in the study did not need to provide a reason nor were they penalized, at any time. Cooperation and contributions of participants were acknowledged confidentially. Additionally, since the researcher also coordinated the SECME program for the school district, there was always a conscious effort to not introduce bias when collecting data through questionnaires and interviews by reporting an array of participant responses and a variety of methods to solicit responses.

1.8 Summary

The United States of America (USA) is in jeopardy of losing ground globally in its representation and innovation in the areas of science, technology, engineering, and mathematics (STEM). The minority population in USA is quickly becoming the majority in many regions. If sufficient attempts at promoting STEM opportunities to youth are not institutionalized, the USA will find itself deficient in meeting the workforce demands and its innovative contributions in these areas, thereby, placing its economy and welfare in the hands of other countries. To address this need precollege programs have been designed to encourage the participation and persistence of minorities in STEM studies and consequently be encouraged to seek careers in these areas. Since the interest and pursuit of science and mathematics, along with academic achievement in those subjects, on average, seem to wane in middle school years, the research focused on the middle grades students. To assist in this area, the school district had instituted the SECME precollege program in schools across the district through a modified version of the national model.

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CHAPTER 2

REVIEW OF LITERATURE

“Scientists thrive on curiosity – and so do children”
(Rutherford & Ahlgren, 1990, p.172)

2.0 Overview

This chapter explores the presence and persistence of minorities in science, technology, engineering and mathematics (STEM), the influences that affect minority achievement and a gender comparison as it relates to academic achievement. The chapter is divided into five sections. Section 2.1 addresses Educational Achievement among Minorities, Section 2.2 the Influences on Achievement, Section 2.3 Approaches to Improve Minority Participation in STEM, Section 2.4 Gender Comparisons with Respect to Achievement, Section 2.5 provides a Program Evaluation through a Curriculum Framework, and Section 2.6, the Summary.

2.1 Educational Achievement among Minorities

The National Science Foundation (2006) released a five-year strategic plan that outlined the plight of science and engineering in the United States of America (USA). While women and minorities increasingly account for a greater percentage of the workforce in the USA, they continue to be underrepresented in science, technology, engineering, and mathematics (STEM) professions. In 1964, the United States Congress ordered a report as part of the Civil Rights Act known as the Coleman Report which found that during segregation, Black children started school trailing behind their white counterparts and the gap persisted throughout their education even when schools were equally equipped; forty years later, this gap still exists (Honawar, 2005; Viadero, 2006). Could this be a result of experiences and exposure at home being significantly different for Black and white children? But why would it persist in school? In an educational setting, students should be exposed equally. Mathematicians solve problems based on real-world experiences and science applies the human values of curiosity, and openness to new ideas and imagination

(Rutherford & Ahlgren, 1990). These innate curiosities and actions towards mathematics and science were expected to be developed in classrooms, but were they? The National Commission on Mathematics and Science Teaching for the 21st Century stated that the products, services, standard of living, and economic and military security will need to come from science and mathematics; "From them will come the technological creativity American companies need to compete effectively in the global marketplace" (Sutman, 2001, p. 20). The National Science Board (2007) indicated that two critical challenges that USA faces in the formation of a strong STEM educational system are coherence in STEM learning and well trained, highly qualified STEM teachers in order to ensure its place as an innovative leader and global technology competitor.

The Center for Education Reform (1998) delineated issues, strategies and policy changes that needed to be addressed if poor educational achievement among minorities was to be changed in the United States. The United States census reported that by 2050, the ethnic minority will represent 50% of the population, a percentage that will only continue to increase (Thomas, 2000). With this trend, there seemed to exist an urgency to address minority educational achievement and postsecondary success. Wildavsky and Marcus (1999) referred to a new federal report on students' enrolment in mathematics and their performance in college. According to this report, "the impact of a tough [rigorous] curriculum is greatest for Black and Latino students, whose college graduation rates still lag far behind whites." The report further noted that taking more advanced math in high school is a key predictor of college completion.

Bushweller (1997) indicated that between 1982 and 1994, there had been a negligible rise in the percentage of high school graduates taking Advanced Placement/Honors courses in Calculus, Biology, Chemistry and Physics. Oddly, Advanced Placement Calculus had its highest percentage of enrolment in 1982 and a dramatic decline through the years leading to 1994. All other course enrolments showed negligible increases, but the data indicated that considerably less than 10 percent of the population of high school graduates had been enrolled in those Advanced Placement/Honors courses. As part of the new American Competitiveness Initiative, $122,000 was appropriated for fiscal year 2007, in part, to increase the number of students taking Advanced Placement–International Baccalaureate mathematics, science, and critical language tests from 380,000 to 1,500,000 by 2012 (U.S. Department of Education, 2006).

> Poor and minority children, by and large, go to worse schools, have less expected of them, are taught by less knowledgeable teachers, and have the least power to alter bad situations. Yet it's poor children that most need great schools. (Center for Education Reform, 1998, p. 2)

According to the Center for Education Reform (1998), by the year 1998, over 20 million students reached their senior year unable to do basic mathematics. Furthermore, in 1996, 13% of all African Americans aged 16 to 24 were not in school and did not hold a high school diploma.

> Given current trends, one of every three (32%) Black males born today can expect to go to prison in his lifetime…Of all persons imprisoned for drug offenses, three fourths are Black or Latino. (Mauer & King, 2004, pp. 2-3)

Studies have also indicated that, over time, minority males tend to become more disengaged from school than girls, especially in high poverty schools (Borman, Stringfield & Rachuba, 2000). In the school system involved in this research, the disparity in student achievement in mathematics and science was being addressed through the improvement of teaching quality and student performance by strengthening the quantity and quality of content exposure in mathematics and science, improving teaching practices in mathematics and science, and accelerating student achievement in mathematics and science (Division of Mathematics and Science Education, 2000).

Literature suggested that less access to advanced mathematics courses and low teacher expectations were significant contributors to minority students' under-achievement in mathematics (Borman, Stringfield & Rachuba, 2000). However, studies indicated that minority students when compared to non-minority students, in grades 5 – 8 expressed greater interest in taking advanced mathematics and science courses (NACME Press Release, 2000). Despite this high level of interest, African American students continued to perform poorly in comparison to non-African

American students on eighth grade standardised achievement and performance tests (Campbell & Hoey, 2000; NCES, 2003) and African-Americans, overall, continued to take fewer higher-level mathematics courses than their Asian and White counterparts (Thomas, 2000). Consequently, with these statistics in mind and their disengagement from school, African American males continued to be under-represented in advanced mathematics and science courses.

To address this problem of under-representation, pre-college programs have been established to help minorities excel in mathematics and science in preparation to enter postsecondary studies in college that would eventually lead to careers in engineering (Hrabowski & Pearson, 1993; Thomas, 2000). Indeed special programs at the college and post-college level have shown that African-American students can excel in science and mathematics (Maton, Hrabowski, & Schmitt, 2000). One such movement began in 1988 with the Meyerhoff Scholars program (Maton & Hrabowski, 2004), continued later by others such as the National Consortium for Educational Access (NCEA), that established a fellowship program to increase the number of African American males nationally receiving PhDs in mathematics and science (Lee, 1996). At the pre-college level, programs like Project Earthquake focused on African American males from K-12 public schools in a certain high-risk region in New York City, and provided enrichment and social activities and resources for students that they may not have received at home (Goldstein, 2007). Similarly, Project: Gentlemen on the Move (PGOTM) incorporated a similar focus for high school African American males and included a teacher professional development component (Bailey, 2003), a goal found similarly in the SECME program.

If Dr. Martin Luther King was alive today, he would be pleased at the sight of the integrated classrooms, but very concerned when taking into account the statistics of Black males attending college (IN FOCUS, 1999).

> The African-American students' high school experiences could explain the decline in college enrolment. Many African-American males get less attention and praise and more criticism than other students. They are seen as threatening and disruptive in the classroom and are more likely to be placed in classes for the

> mentally retarded or emotionally disturbed (Hrabowski & Pearson, 1993, p. 27).

This was very obvious in the enrolment of minorities in the local prison system and specialised learning centers in the school system involved in this research. In 2000, the school system in this study ranked first with respect to the number of youth referred to the juvenile justice system for delinquency and the number of at-risk students in the state, and accounted for approximately 25 percent of the total number of students in the juvenile justice system (Department of Research Services, 2000). High expectations and reinforcement of positive behavior as opposed to criticism and intolerance has demonstrated a constructive impact on reducing student discipline referrals in school districts (Adams, 2008).

The African-American male's success is a complicated combination of peer and parental expectations, overcoming societal stigma and stereotypes, while being provided the opportunity to participate in an educational environment that is supportive with high expectations. Hrabowski III (1998) recalled that as a Black child growing up in the 1950s and 1960s, parents and family were critical to his development by making him feel special in their lives and preparing his successful future in two ways: 1. by ensuring he was well prepared academically; and 2. the expectation that he would 'give back' (Hrabowski III, Maton & Grief, 1998). Unfortunately, the perceptions of African American males through the eyes of many, if not most Americans, are typically not complimentary of their academic successes. Even teachers hold low expectations for minority students and their ability to achieve at high standards or even progress to college levels (Garibaldi, 1992). Hrabowski III observed that most portrayals of young African American males focus on what is seen and heard about them with respect to "problems of crime, violence, drugs, teenage pregnancy, and poor academic achievement" (Hrabowski III et al., 1998, p. 3).

Moreover, there does not seem to be consensus as to the reasons for the negative plight of young African American males (Hrabowski III, et al., 1998). Some blame urban problems, increased drug usage, decline in the economy, and the desire to take an easier road towards instant gratification. Bryant (1993) believed that there existed a resurgence of racism, and African American youth succumbed to peer and cultural pressure that viewed academic success and learning as “acting white” (Bryant, 1993, p.18). Perhaps it was the lack of value placed on education as proffered by Hrabowski and Pearson (1993) that presented the unwillingness of African American males to enrol in advanced classes, thus adding further limitations to their opportunities in pursuing mathematics and science-related careers (Hrabowski & Pearson, 1993). Even today, racial tensions are high and educators are urged to focus not only on academic achievement of African Americans but also on the social climate of the schools (Maxwell, 2007).

2.1.1 Minorities in STEM

The presence and persistence of minority males in STEM courses in postsecondary education and careers in some instances showed a meager improvement ten years ago. However, the pervasive enrolment gap between Whites and African-Americans or Hispanics at the undergraduate and graduate levels in science, engineering and mathematics were still unacceptable. Not surprising to this researcher, African-American women had higher representation than did African-American men. According to the National Science Foundation (NSF) the statistics spoke for themselves (NSF, 1998).

> In 1995, African Americans, 12 percent of the total U.S. population, earned just over seven percent of all bachelor’s degrees and almost 7 percent of all science, mathematics, and engineering bachelor’s degrees awarded in 1995, were up slightly from 1989. African American women had greater representation than African American men, earning over 4 percent of all undergraduate degrees and just over 4 percent of all science, mathematics, and engineering undergraduate degrees awarded in 1995. African American men earned over two percent of all degrees awarded and almost three percent of science, mathematics, and engineering degrees.
>
> Hispanic men and women made up 10 percent of the U.S. population and earned almost 6 percent of all bachelor’s degrees awarded in 1995 and over five percent of all undergraduate degrees awarded in science, mathematics, and engineering in that year. Hispanic women had slightly higher numbers than Hispanic men, earning over three percent of all bachelor’s degrees and slightly less

> than three percent of science, mathematics, and engineering degrees awarded in 1995 (NSF, 1998, pp. 40-42).

The statistics for minorities earning science and engineering and non-science or engineering Bachelor's degrees has only increased by 7 percent, as of 2006 (National Science Foundation, 2009). With the minority population, today, larger than the entire population of the United States in 1910, and Hispanics the fastest growing (Bernstein, 2007), an exerted effort must be made to attract these groups to STEM education and careers. Instructional pedagogy on cultural sensitivity should be enhanced to nurture the bicultural diversity of Hispanic students who bring bilingual strengths to the country and its place in the global economy (Rolon, 2002).

2.1.2 Achievement gap

Viadero (2005) commented that students in schools with predominantly Black or Latino populations tended to perform more poorly than students from the same racial and ethnic groups attending schools with diverse populations. Even when the minority was the majority, the gap between minorities and the majority existed within the school. So, why should an achievement gap exist within these groups? Viadero (2005, p.6) cited that the Princeton, NJ-based Educational Testing Service found in its study of the achievement gap that from 1992-2002 a "pervasive, profound, and persistent" gap existed between minorities and non-minorities. Schools across the district involved in this research portrayed this gap even with a common curriculum and expected teaching standards.

Flaxman (2003) noted that minority student performance correlated to teacher expectations and encouragement and concluded that teachers and schools, in general, could help close the achievement gap. There were four points discussed. The first point was that teachers and schools should expect that all students can achieve and motivate minority and non-minority students equally. The second point was that schools should identify and respond to deficits in knowledge and skills of minority groups that tend to self-report problems understanding content and perform poorly on standardised tests. The third point indicated that teachers should provide encouragement to students in a routine. The fourth point allowed for the provision of educational resources and experiences to counteract disadvantages due to family backgrounds. Students living in low socioeconomic environs, in comparison to their more affluent peers, need exposure to resources and experiences that they would not typically receive at home. Schools may be the only source of these exposures for some students. These experiences become even more imperative for those who will become first generation college enrollees and graduates.

Bryant (1993) described African-American students and their teachers leaving school to be a shocking scene. He noted that from grades 7–12 most students were not carrying any books, a scenario that was not conducive to learning beyond the school day. However, where does the disinterest in carrying books and excelling academically stem from? Black males in America for the most part deem academics as not cool and relate cultural identity to being non-academic; often, students displaying academic success or being "smart" met with ridicule from peers (Bryant, 1993; Thomas, 2000). Additionally, the Black person, unlike the White Hispanic, is almost always identifiable by his/her most obvious physical characteristic, skin colour. Therefore, whether one is of Caribbean, Latin American, British, or other nationality, he/she is often at first sight categorised as African-American if residing in the United States (Hrabowski III, Maton & Grief, 1998). Thus, upon initial encounters with students, typically, all stigmas and expectations would be associated with the pigmentation of one's skin colour as opposed to one's cultural background and more heinously prejudged by stigmas rather than individual abilities and potential, and without regard for high expectations of all students.

2.2 Influences on Achievement

Walberg's theoretical framework for the Educational Productivity Model can be categorised into three areas - student aptitude, instruction, and psychological environment - that examine specific factors associated with achievement and learning outcomes (Thomas, 2000). There are nine educational productivity factors that influence each other and subsequently student learning.

> Student aptitude includes: a) ability or prior achievement; b) development; and c) motivation or self-concept. Instruction encompasses: d) the amount of time students engage in learning, and e) the quality of the instructional experience. The environmental factors include: f) the home, g) the classroom social group, h) the peer group outside the school, and i) use of out-of-school time. (Thomas, 2000, p. 167)

Thomas (2000) further inspected the nine productivity factors. *Ability/Prior Achievement* was found to indirectly affect mathematics achievement and confidence in understanding concepts and time spent on homework assignments, however, for minority students, standardised test achievement scores may not serve as a sufficient predictor of mathematics achievement. Unfortunately, in today's educational accountability and determination of student success, minority student achievement is constantly being measured by standardised tests.

Motivation and Attitude allowed for students to participate in academic activities and therefore linked to achievement. However, academic grades in high school were found to be a predictor of attainment of a college degree and not just the motivation or attitude as exhibited by some students who expect to attend college with poor grades (Rosenbaum, 2004). Treagust (1989) also noted that exemplary teachers motivated students by encouraging them to engage in and take full advantage of learning opportunities.

The number of higher-level mathematics courses students enrolled in indicated the *Quantity* of mathematics instruction. Research indicated that the achievement gap diminished when students were engaged in rigorous and higher-level courses, however, enrolment in these courses were still influenced by home and school environmental factors as well as motivational variables. The strongest predictor of academic preparation for college was taking rigorous and intense courses in high school (Rosenbaum, 2004).

The Quality of instruction referred to teachers teaching to students' thinking processes and that teachers' behavior and expectations were related to achievement. Peters (2004) quoted an eleventh grader as saying, "Students are looking for the connection of what the teacher is trying to teach to why do I need to know this?"

Hands-on science provides these types of connections and is a prime outlet for students of second-languages because, through hands-on activities, their acquisition of content is not necessarily language-dependent. Science allows students to develop from simple to more abstract thought by transitioning from describing the "here and now" to hypothesizing the "what will happen" (Lee & Avalos, 2002). Science inquiry and real-world applications can transcend language barriers, but teachers need to be aware of educational beliefs and cultural differences. Lee and Avalos (2002) discussed literacy development of English Language Learners (ELL) and reminded that cultural beliefs should be addressed when incorporating scientific inquiry because some cultures believe in the teacher centered – teacher always right and the source of answers – classroom and need to be encouraged and guided to a more learner centered environment. These English Language Learners comprised the majority of the participants in this study, specifically those of Hispanic background. Furthermore, the ELL strategies best suited to develop their literacy is especially relevant since the essence of the precollege engineering program is grounded in hands-on STEM activities designed to engage students.

The *Home* environment was important for minority students in that parental education and expectations affected participation and career choices. Between 1972 and 1982, the achievement gap between whites and Latinos or Blacks decreased as a result of families gaining financially and becoming better educated (Viadero, 2005). However, as Navarette (2005) explained, Hispanic parents were the most undereducated of all minority groups and this represented a significant disadvantage to their children because children whose parents are successful and well-educated have an advantage. Because immigrant parents are often struggling and focusing on work, this only portrays to their children that they too can survive in the USA without an education (Navarette, 2005).

The *Classroom* environment included not only interactions with teachers but also with fellow students. *Peers* were found to significantly affect student attitudes and moderately learning outcomes, especially among African American students. Use of *Out-of-School* time included time to engage in intellectually stimulating activities and less television time that negatively impacted learning outcomes.

When taking into account the major ethnic and language minority groups in the United States, there have been some improvements made by Hispanics and Native Americans on mathematics and achievement tests; however, African-American students continued to exhibit the least amount of improvement (Thomas, 2000). With respect to mathematics achievement, Thomas (2000) further suggested that among

African-Americans, Hispanics and even White students the motivation and the desire to succeed had positive effects on achievement.

2.3 Approaches to Improve Minority Participation in STEM

Over the years, efforts have been made to close the achievement gap and increase the minority participation in and successful completion of postsecondary studies in STEM. The United States Department of Defense has demonstrated increased student achievement by involving middle school African American and Hispanic students in out-of school "supplementary academic" experiences that enhance student socialization and academic skills while involving the community and parents (Research Points, 2004).

The National Research Council (1979) indicated that minority students should be exposed to engineering field trips, minority role models, gain experiences in technical work and receive awards to motivate students to study engineering subjects and enhance communication skills. The Council further delineated four qualities of effective pre-college engineering programs:

> (1) identify students with the potential ability and interest to become engineers; (2). provide academic counseling and assistance that will assure entry into an engineering program or college; (3). supply career-related information; and (4) make clear to the students the need to relate their academic experiences to their expected careers. (NRC, 1979, p. 12)

One strategy used to assist in the closure of the achievement gap between minority students and white students was the inception of SECME. Originally developed in 1975 as the Southeastern Consortium for Minorities in Engineering, the pre-college program provided alliances for school systems with engineering schools in universities, as well as corporate and government partners for public school students in grades 6-12. A critical focus of SECME was to improve mathematics and science literacy and to increase the participation and persistence of minorities in postsecondary engineering studies. The program acknowledged that low achievement in mathematics and science affected student choices of careers and college courses, which in turn impacted the quality and future of society as a whole. Thus a strategic alliance among public schools, universities, industry and government agencies was created. Today, the SECME Alliance extends beyond the southeastern region of the United States of America to Nevada on the west coast and north to New York State. In 2001, the Southeastern Consortium for Minorities in Engineering - S.E.C.M.E. - became SECME, Inc. and the acronym was dropped. The goal of SECME is to increase the number of African American, Hispanic and Native American students in post-secondary studies in mathematics, science, engineering and technology (SECME Corporate & Foundation Case Statement, 2001).

Public schools in the district targeted for this research were invited and encouraged to participate in the SECME program which was managed from the School District or Central office in the Division of Mathematics and Science Education by a team of two educational specialists (teachers on special assignment) and administrative co-directors. The school district indicated that mathematics achievement, since 2001, had increased for middle school minority group students in grades 6 and 7. In grade 8, however, African Americans and Hispanics dropped by 3 scale scores on the state achievement test between 2001 and 2002 (Blazer, 2002). The concern was two-fold. If minority students in grade 8 continued the downward trend, the gap between minority and non-minority students would increase dramatically, and if all groups improved equally, the achievement gap would still persist. The intent of SECME and all other district initiatives was to narrow the gap through minority achievement increments surpassing that of non-minority achievement incremental gains.

2.3.1 Teacher-student interaction

Students spend a considerable number of hours in school. According to Fraser (1998), by the time students have graduated from high school, an estimated 15,000 hours had been spent in the classroom. The environment in which students spend that quantity of time must influence their social and psychological impressions of their learning environment. Fraser (1998) indicated that student perceptions accounted for variances in learning outcomes beyond student background characteristics. The interaction that students have with their peers and teachers should certainly affect their academic achievement, but to what extent and how would the effects be measured? The intent of the SECME program implemented in the district involved in this study was to provide opportunities for these interactions. SECME teachers often spent Saturdays with their peers and students while engaged in engineering workshops and worked with students after school daily, for several weeks, when preparing for competition. In order to improve teaching and learning, instructors needed to be engaged in professional development that provided a support network, opportunities to collaborate and share experiences while promoting intellectual growth (Gibbons, Kimmel, & O'Shea, 1997). These professional development experiences should also include interpersonal relationships with students.

The relationship between teacher and student, as noted by Wubbels (1993), could be a key factor in student learning. Fraser (1998) summarised the importance of assessing learning environments and their implications professionally and bureaucratically for the following seven reasons: first, to provide information about classrooms; second, to solicit feedback from students regarding their classroom perceptions which may be contrary to their teachers' perceptions; third, to use research findings to create 'productive' learning environments; fourth, for teachers to strive to improve student outcomes by changing learning environments to match students' preferred environments; fifth, to use classroom environment assessments when evaluating innovations, new curricula and reform efforts; sixth, to use data of actual and preferred environments to improve classrooms and schools; and seventh, to assist school psychologists to facilitate teachers' interactions with students to improve classroom and learning environments.

This study aimed at analyzing the intent of the SECME program with respect to motivating students through STEM activities and interactions that involved students and their teachers and parents working together. Modified versions of learning environment instruments such as the Test of Science Related Attitudes (TOSRA) (Fraser, 1982), Test of Mathematics Related Attitudes (TOMRA) were used to assess SECME and non-SECME students' attitudes towards science and mathematics while researcher-developed questionnaires attempted to assess students' perceptions of the SECME learning environment.

2.3.2 Extracurricular programs

Extracurricular and after-school programs focused on college awareness/preparedness and provided academic enrichment opportunities that attempted to provide minority students with experiences which they may not necessarily be exposed to during the traditional school setting. Targeting minority students in these activities was especially critical since "[B]lack students need to be shown that development of their minds can bring economic success, personal fulfilment, respect, and appreciation from others (Bryant, 1993, p. 18)." These academic-focused, extracurricular programs were essential for many African American students who succumb to anti-academic peer pressure outside these settings (Thomas, 2000).

Precollege programs show students that college is an attainable goal for anyone, especially low income urban youth who may not have access to quality science clubs or other academic enrichment programs (Ascher, 1991; Rahm et al., 2005). Furthermore, the field of science is represented by individuals of all ethnicities, gender and nationalities (Rutherford & Ahlgren, 1990). According to Bryant (1993, p. 18), "Universities should recruit academically talented Black students from urban schools with the same aggressiveness they recruit Black athletes." Reports showed that students who participated in the pre-college program, SECME, on average, were more successful academically and performed better on criterion and norm-referenced tests than did their peers who were not involved in the program. A report compiled by the school district's Division of Mathematics and Science Education (Sanjurjo, 2005) indicated that Exceptional Student Education and standard curriculum SECME students outperformed their peers in the District on the criterion-referenced Florida Comprehensive Assessment Test Sunshine State Standards and the norm-referenced Florida Comprehensive Assessment Test in the areas of reading, mathematics and science, and in some areas, outperforming their peers statewide and nationally. (Data showing these trends are presented in Note 1 prior to the Appendices)

Even though after-school, informal settings such as those found in programs like SECME could benefit all students, Bryant (1993) emphasized that formal learning restricted to the hours between 8 a.m. and 3 p.m. were particularly socially and economically demoralising for African-American students and the nation's needs. Formal before- and after-school programs were found to provide a positive environment where all students were safe, and afforded social adjustment and academic enrichment opportunities (Posner & Vandell, 1994; Witt & Baker, 1997).

Witt and Baker (1997) found these programs to be most critical for students between the ages of 10 and 14. Posner and Vandell (1994) even found a correlation between time spent in after-school programs and students' academic and conduct grades, peer relations, and emotional adjustment. Students of lower socioeconomic status tended to have fewer opportunities to participate in after-school science clubs and programs when compared to their more affluent peers (Rahm, Moore, & Martel-Reny, 2005). After-school programs tended to build confidence in students who participated and kept students out-of-trouble in a safe environment (National Education Association, 2000). Rahm, Moore, & Martel-Reny (2005) positioned that students pursued after-school experiences as a result of support and encouragement from their peers, teachers and/or parents and even improved self-confidence, a trait commonly found in the culture representing the mainstream majority. Thomas (2000) also pointed out that Asian-American students tended to maintain a higher level of achievement as a result of spending less time watching television and more time participating in more mentally stimulating activities.

After-school programs, which include weekends and late-night activities, also provided a structured environment that exposed children to academic and enrichment activities, therefore, decreasing the amount of time spent watching television and the possible engagement in violent crime to which children of poverty are more prone (Posner & Vandell, 1994; Witt & Baker, 1997). Children in these environments interacted more positively with their peers, were exposed to role models, and were provided academic support that were often lacking in many inner-city youths homes (Witt & Baker, 1997). However, after-school activities need to be grounded in compelling everyday issues, be interesting, challenging and relevant to engage restless youngsters (Kliman, 2004).

2.3.3 Role models

Black students need models in the science and engineering fields from as early as elementary school (Bryant, 1993). Industry and university colleagues could work with schools demonstrating why students should prepare themselves for careers in those fields. Witt and Baker (1997) agreed that including in after-school programs scholastic support and/or role models that were typically lacking in the homes could result in an increase in school attendance and grades, therefore, positively impacting the drop-out rate of older children. Middle school students seemed to be most impressed when exposed to successful skilled tradesmen and professionals who had volunteered to participate in after-school programs (Griffin 2005). Jones and Smith (2003) found role models and mentors especially important for African-American males. Minority students need role models, especially African-American teachers for African-American students, specifically those teachers who have high expectations and believe that their students can perform at high levels (Joiner, 2003). Bryant (1993) concurred that "Black students will produce if they perceive you are genuinely interested in their welfare" (p. 19).

2.4 Gender Comparisons with Respect to Achievement

Adolescent males are more likely than adolescent females to die from suicide and homicide, drop out of school, and are less likely to pursue higher education, a trend even more prevalent for African-American males. Jones and Smith (2003) posited that more African American males were going to prison rather than postsecondary education and that their counterpart females persist longer in school. The conclusions from these findings were that more African-American males were headed for prison rather than college (Jones & Smith, 2003). Joiner (2003) pointed out that incarceration, the stigma of which could affect future employment opportunities, and re-entry to society, was viewed in some communities as a "normal" part of experiences for African-Americans; citing that African-American youth make up 44 percent of all youth detained, 46 percent of youth sent to adult court and 58 percent of youth sent to adult prisons.

The middle school aged male had been appearing in the news frequently over the past few years in connection to violence and incarceration: USA Today headline – S*tudents had hit list, mayor says; Alleged plot for massacre at Alaska school disrupted two days after five teens arrested in Kansas* (Johnson, 2006); Boston Globe – *Spike in violence in middle schools raises concerns* (Jan, 2007); DeLand, Florida – *New threat of school violence creates fear on DeLand campus* (WFTV.com, 2008). Males seemed to be predominantly at-risk at the adolescent years for social misbehavior and lack of academic achievement, regardless of ethnicity. Joiner (2003) provided the astonishing statistics of 11 year olds to 14 year olds being charged and convicted of such crimes as homicide and second-degree murder. Moreover, there was overrepresentation of Black youth in all areas of the juvenile justice system, from arrest to detention. Griffin (2005) indicated that more exposure to positive male role models for African Americans influences youth by mitigating the forces that can lead to high risk behavior for criminal activity, ill health and even premature death.

2.5 Program evaluation through a curriculum framework

When determining the effectiveness of a program, one should look to the definition of curriculum or 'plan for learning' (van den Akker, 2003). van den Akker (1998, p. 421) described curricula representations as:

- *Ideal*: the original version underlying a curriculum (basic philosophy, rationale or mission);
- *Formal*: the vision elaborated in a curriculum document (with either a prescribed/obligatory or exemplary/voluntary status);
- *Perceived*: the curriculum as interpreted by its users (especially teachers);
- *Operational*: the actual instructional practices in the classroom, as guided by previous representations (also often referred to as the curriculum-in-action or the enacted curriculum);
- *Experiential*: the actual learning experiences of the students;
- *Attained*: the resulting learning outcomes of the students.

This framework could also be translated to specialized programs. The *ideal* curriculum, in the instance of this study, would be the program created by the Deans of the seven Southeastern engineering colleges in 1975 and their mission to increase the minority presence in engineering. The *formal* program was realized with the formation of a competition program and alliance with local member universities in the various participating school districts. The *perceived* curriculum would actually become two-pronged. At the district level, by the organizers and at the school-site, by the teachers who implemented the program with the students. The *operational* would be accomplished by both the district staff and the school-site teacher coordinators of the program. The *experiential* program occurred when the students, teachers, and parents participated in the Saturday Engineering Design Seminars and competition offered by the district office and at the school-site. The *attained* program results would prove to be the most difficult to ascertain. Attitudinal surveys and/or achievement tests could provide implications for what was attained as a result of the program, however, ideal would be a longitudinal study that would track students from K – 16 through career selection.

This study implemented the broader definition of the aforementioned curricula representation into the intended, implemented, and perceived/achieved program because the effects of the program delivered from the district perspective was the intended exploration. Other studies have used this four-part curriculum framework to identify best teaching practices and curriculum design (Hartley, 2002; Treagust, 1989). A description of each follows.

Table 2.1 Typology of curriculum representations (from van den Akker & Voogt, 1994)

INTENDED	*Ideal*	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/Written	Intentions as specified in curriculum documents and/or materials
IMPLEMENTED	*Perceived*	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (also: curriculum-in-action)
ATTAINED	*Experiential*	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Intended

There often exists a gap between the intended curriculum or program structure envisioned by the organizing entities and the experiential curriculum or program that is experienced by the students (van den Akker & Voogt, 1994). Often entities such as organizations or school districts create programs or curricula that are intended to meet certain needs, but by the time it is interpreted or translated into documents for dissemination and interpreted by teachers, then delivered to students, the experiences that students receive may not be the exact intent. There is a need for fidelity of implementation of programs and curricula if they are to be evaluated as effective. However, because there are so many variables involved, especially the human variable, it is often difficult, if not impossible, to stick entirely to the “script” of an intended curriculum or program because each individual teacher or presenter has his/her style and/or interpretation of what and how the material is delivered.

Therefore, it is essential that professional development is provided up-front to introduce the philosophy and goals of the program and/or curriculum as well as to set clear expectations of its implementation. In this study, the intended curriculum is the district model of implementation of a precollege engineering program. It must be stated, however, that this model may vary slightly from the originally intended program established by the national founding universities. These differences would be a result of the same issues that plague all new curricula and/or programs.

Implemented

When teachers implement the curriculum or program, they rely on their pedagogical preferences, content background, and inherent biases. They must consciously be aware of their practices and constantly reflect on whether these practices are in alignment with the intent of the program and/or curriculum that they are implementing. This proves to be the tension between their practices and fidelity to the intended curriculum/program. Instructors typically do not change their practices until their ideologies align with a new program/curriculum and they have had ample opportunity to internalise it (van den Akker, 1998).

Attained

How the targeted audience responds or reacts to the curriculum and/or program introduces an additional variable and potential loss of intent, since, once again, attainment is subject to the recipients' interpretation and internalization of what is implemented.

2.6 Summary

The presence and persistence of minorities in science and mathematics, the influences that affect minority achievement and gender comparisons as they relate to academic achievement are factors that contribute to the achievement gap. Unless all students, especially minority students, were encouraged to stay in school and provided with the resources to pursue advanced mathematics and science courses, the United States would be without the local talent to meet the needs of its science, technology, engineering, and mathematics (STEM) workforce, not to mention, maintain its competitive edge globally.

Special attention focused on minority education that eradicates the achievement gap is critical, as the minority will eventually become the majority. The United States census predicts that minorities will represent 50 percent of the population by 2050.

After-school and enrichment programs that provide students with safe, motivational, academically rich learning environments may be the resource to provide the positive academic reinforcement for minority students.

Walberg's theoretical framework categorised by student aptitude, instruction, and psychological environment examined specific factors associated with achievement and learning outcomes. The nine educational productivity factors that influence each other and subsequently student learning encompassed ability/prior achievement, motivation and attitude, quantity of instruction, quality of instruction, home environment, classroom environment, peers, and use of out-of-school time (Thomas, 2000).

Specialised precollege programs such as SECME have been developed to help close the achievement gap and encourage students to participate in and successfully complete postsecondary studies in STEM. The program seems to address many of the educational productivity factors. Further analysis, through a curriculum research framework evaluation (van den Akker, 1998), would reveal the intent, implementation and attainment of the program goals. The intent of the SECME program in the school district involved in the study was to increase historically underrepresented and underserved student populations' achievement in science and mathematics while providing precollege engineering exposure and experiences to better prepare them for postsecondary education in these areas. The program was directed at K–12 students and their parents, and at the same time provided teachers with professional development, instructional resources and support for effective implementation.

at district sponsored engineering eventsfrican-American male students, would provide exposure to role models and experiences that they may not typically be involved in at home or at school. An analysis of quantitative and qualitative data would reveal the implementation and the attainment of the intent of SECME. However, it should be noted that as indicated by Thomas (2000), for minority students, standardized test achievement scores may not serve as a sufficient predictor of mathematics achievement. As Rosenbaum (2004) indicated, the strongest predictor of academic preparation for college was the enrolment in rigorous and intensive courses in senior high school, which may prove to be an important future analysis of the SECME program through a longitudinal study.

CHAPTER 3

METHODOLOGY

The intent is to provide program participants with 1) exposure to institutions of higher learning, 2) engagement in hands-on, critical-thinking engineering activities, 3) networking opportunities among families, students, teachers, community partners, and K16 educational institutions, and 4) mentoring and coaching by minority K-12 faculty, engineers, and engineering students. (School District SECME model).

3.0 Overview

This chapter identifies and describes the research methods used to answer the research questions stated in Chapter 1. There are eight sections in this chapter. Section 3.1 describes the research framework. Section 3.2 explains the research design. Section 3.3 discusses the aim of the study and presents the research questions. Section 3.4 illustrates the research setting and student sample. Section 3.5 describes the design of the intervention program. Section 3.6 provides an overview of the data sources. Section 3.7 explains the data collection and analysis procedures. Section 3.8 discusses the ethical issues and Section 3.9 summarises the research methodology.

3.1 Research Framework

A Research Framework for Curriculum Evaluation was used to evaluate the effectiveness of SECME since, in essence, it is a "specialised curriculum." The intent of the program, how it was implemented, and the perceptions and achievement of the students involved in the program were used to frame how the research questions were answered. The intended curriculum was documented in the focus and mission of SECME. The implemented curriculum was evidenced through observations of the activities provided to the participants. The perceived and achieved curricula were evaluated by questionnaires and assessments such as the Test of Science Related Attitudes (TOSRA), Test of Mathematics Related Attitudes (TOMRA), researcher-developed questionnaires, and the Florida Comprehensive Assessment Test (FCAT), respectively. The TOSRA and the TOMRA were both modified due to the length of the original questionnaires and the relevance of only some of the scales to this research. Both instruments had been administered to middle school students in other studies (Ogbuehi & Fraser, 2007; White & Richardson, 1993).

The *intent* of SECME nationally and locally were ultimately the same, to increase historically underrepresented and underserved student populations' achievement in science, technology, and mathematics while providing precollege engineering exposure and experiences through an alliance with industry, government and industry partners. The main difference between the national and local SECME program intentions was that, locally, the focus was directed at K–12 students and their parents, and at the same time providing teachers with professional development, resources and support. At the national level, the focus was primarily the teacher. However, it must be reiterated that the end result of increased student participation in STEM was the intended outcome for both. The ideal implementation of SECME in the school district was accomplished by schools having teams of teachers, counselors and administrators working with students and parents.

Ultimately, the program would be implemented as part of the classroom curriculum and as an after-school enrichment program that provided STEM opportunities and exposure to historically underserved and underrepresented students in those fields. Schools would host engineering design seminars for students and provide in-house competitions. A school climate of high expectations and encouragement of students to excel in mathematics and science would exist among the entire staff. Teachers would target minority students and actively recruit them into the program. There would also be collaboration among neighboring elementary, middle, and high school SECME students to articulate and transition smoothly into already existing SECME schools. The students would participate in school-site as well as district sponsored activities and competitions.

3.2 Research Design

Primarily, the research was carried out through the use of a mixed method (Anderson, 1998, Cohen, Manion & Morrison, 2002) that included a pre-posttest design using surveys and questionnaires of 12 active SECME middle schools. At a workshop, teachers participating in the SECME program were introduced to the modified TOMRA and TOSRA pre/posttest survey. Participants were informed that the surveys would be sent to their schools in the fall, between October and November. Directions were included with the modified TOMRA and TOSRA to ensure that surveys would be administered with fidelity and equity (see Appendices

A2, B and C).

The researcher collected the completed surveys from each school and compiled the data. In the spring, the posttests were sent to schools and collected in June. Pre and posttest data were combined and analysed. Interviews, observations, and researcher-developed questionnaires were included as part of the data collection.

More in-depth case studies were conducted with three targeted schools from the SECME program. The literature suggested that using case studies as a research method was valuable and appropriate, especially with respect to developing a deeper understanding of a phenomenon such as the effects of specialised programs on student achievement in mathematics and science. Anderson (1998) explained that a case study allowed for intensive analysis, therefore, limiting the researcher overlooking critical information. As a part of the case study, face-to-face interviews, questionnaires, and observations in natural school settings provided a better understanding of student motivations and their responses to and interactions with teachers and peers during SECME meetings and SECME Saturday Engineering Design Seminars.

A triangulation strategy was used in this study to increase the validity of research. Mathison (1988) described two types of triangulation strategies that would be used during this program evaluation. Data triangulation as "the inclusion of more than one individual as a source of data....understanding a social phenomenon requires its examination under a variety of conditions" (p. 14). In this research, multiple students and teachers were observed in a variety of settings. Methodological triangulation uses multiple methods, such as interviews, questionnaires, and observations to examine the phenomenon of the case study. "The rationale for this strategy is that the flaws of one method are often the strengths of another: and by combining methods, observers can achieve the best of each while overcoming their unique deficiencies" (Denzin, 1978, p. 302).

Test scores attained from the Florida Comprehensive Assessment Test (FCAT) from the current year of study were analysed and compared to the district and state average mean scale scores. Since Punch (1998) notes that in comparative case studies

"...the focus is both within and across cases" (p. 152), participants for the case study were selected from three different middle schools. This use of both data triangulation and methodological triangulation (Mathison, 1988) were used to gain a more complete examination of the SECME program.

3.3 Aim of the Study and Research Questions

The aim of this study was to evaluate the presence and participation of grade-8 students in a precollege engineering program by analysing the intent of the program, the implementation of the program, and the actual program outcomes. Of particular interest were students' attitudes towards science and mathematics and their academic achievement in science and mathematics. As discussed earlier in more details, both SECME and non-SECME students were involved in this research. Essentially data were collected from the SECME students – the target group – and their non-SECME classmates who choose to respond to the questionnaires.

Research Questions

1. What is the intention of the SECME program?
2. How is the SECME program implemented across the District?
3. What are the reliabilities of the modified scales of the Test of Science Related Attitudes (TOSRA) and the Test of Mathematics Related Attitudes (TOMRA)?
4. What are the changes in SECME and non-SECME students' achievement in science and attitudes towards science following their experiences in a precollege engineering program?
5. What are the changes in SECME and non-SECME students' achievement in mathematics and attitudes towards mathematics following their experiences in a precollege engineering program?
6. What is the relationship between attitudes towards science/mathematics and academic achievement following their experiences in a pre-college engineering program?
7. What are students' parents', teachers' and researchers' reflections on minorities' achievement in science and mathematics?

3.4 Research Setting and Student Population

The setting for the study was in an urban school district, in the southeast region of the United States of America (USA). At the start of the study, the district represented the fourth largest school system in USA with 348 schools and a population of 369,578 students (Statistical Highlights, 2004). By the conclusion of the data collection, there were eight additional schools and surprisingly 4,206 fewer students enrolled in the public school system. Although the decline in enrolment was evident in grades six and seven, interestingly, grade eight populations increased in three sub-categories. There were 267 additional Black non-Hispanic students enrolled, 393 Hispanic and 91 in the Other ethnic distribution category. The only subgroup in grade eight showing a decrease was the White non-Hispanic. These statistics are provided in Table 3.1.

Table 3.1 Ethnic distribution of school district by grade level for 2003-04 and 2004-05

	Percentage							
	White Non-Hispanic		Black Non-Hispanic		Hispanic		Other	
Grade	03-04	04-05	03-04	04-05	03-04	04-05	03-04	04-05
6	2,763	2,653	9,026	8,156	17,267	16,821	664	659
7	2,888	2,699	8,649	8,423	17,668	17,173	643	636
8	2,915	2,806	8,175	8,442	17,402	17,795	548	639
Total	8,566	8,158	25,850	25,021	52,337	51,789	1855	1934

The school district was sub-divided into six regions. The ethnic distribution among the schools within each region during the research period is depicted in Tables 3.2 and 3.3 for 2003-04 and 2004-05 of the study, respectively.

Table 3.2 Ethnic distribution of school district in percentages by region for 2003-04

	Percentage		
	African-American	Hispanic	White
Region 1	23	72	4
Region 2	57	29	11
Region 3	38	57	4
Region 4	7	72	17
Region 5	7	72	17
Region 6	24	59	13

Table 3.3 Ethnic distribution of school district in percentages by region for 2004-05

	Percentage		
	African-American	Hispanic	White
Region 1	22	73	4
Region 2	57	29	11
Region 3	38	57	4
Region 4	28	64	7
Region 5	9	70	17
Region 6	24	59	13

As indicated in Table 3.3, Regions 4 and 5 seemed to experience the most obvious shift in demographic distribution. Region 4 increased the African-American population by 21 percent and the Hispanic population decreased by eight percent.

Students in public school grades K–12, traditionally, attended elementary schools for kindergarten to grade-5, then middle school grades 6-8, and high school grades 9-12. The district also offered specialised programs that were either housed within a school or self-sufficient schools known as magnet schools.

> Magnet programs/schools:
>
> - cater to the unique interests, talents, and abilities of students;
> - offer excellent educational opportunities;
> - can lead to scholarship opportunities at colleges and universities;
> - offer specialized studies in areas such as the arts, foreign languages, and creative writing;

- provide school-to-career path exploration; and promote multicultural collaboration among students. (Miami-Dade County Public Schools, 2009)

Each year, the SECME school-site teacher leader/coordinator was required to submit student information and an intention to participate in the SECME program. This information was sent to the District and National program offices. Tables 3.4 and 3.5 depict the participation of middle schools and District SECME student membership, respectively.

In 2004-05, the number of middle grade students that were reported participating in SECME had increased in grade-8 for the African American and White ethnic subgroups. White student participation had increased the most in grades 6 and 7. Interestingly, the Hispanic student enrolment decreased across each of the grade levels 6-8.

3.4.1 The Middle Schools

The middle schools in the district encompassed grades six through eight with students ranging in age from approximately from 11–14 years. There were a total of 54 middle schools in the district. The district was divided into six regions. There were 10 middle schools that participated in the research study during year two. The profiles of these schools are indicated in the Table 3.4.

Table 3.4 School Profiles of Participating Middle Schools

School	% Beginning Teachers	% Faculty New to School	Pupil/ Teacher Ratio*	% White	% Black	% Hispanic	% Other	% Free/ Reduced Lunch
1.1	13.2	19	16:1	3	1	96	0	84
1.2	15.8	15.4	23:1	1	87	12	0	86
1.3	14.7	17.1	27:1	8	14	75	2	61
1.4	19.2	21.3	23:1	4	49	46	2	83
1.5	5.0	14.9	22:1	3	2	95	1	85
3.1	14.3	11.5	21:1	6	13	80	1	75
5.1	17.3	22	22:1	7	2	89	2	62
5.2	11.4	15.8	18:1	45	13	36	6	20
5.3	12.3	25.6	20:1	36	23	33	8	31
5.4	14.5	25.7	24:1	5	1	93	1	80

*Note *regular school program*

3.4.2 Student sample

The research involved students at 10 middle schools in Miami-Dade County and more in-depth case studies of three targeted SECME schools. SECME teachers at these schools were asked to survey their SECME students and all grade 8 Language Arts classes. The Language Arts class was used as a mechanism to provide a neutral setting to avoid teacher or student bias since the surveys were focused on mathematics and science attitudes. Once all surveys were returned to the researcher, the responses were disaggregated by SECME and non-SECME participation, gender, and ethnicity.

The study was designed to take place over a two-year period and focused initially on minority males in the middle school grades 6-8 because a review of literature indicated that these were the most at-risk group of students for dropping out and getting caught-up in the criminal system (see Chapter 2.1). However, in the first year, 2003-04, there was only a small pre-posttest matched sample due to low return of the posttest student responses by the teachers to the researcher. In the pretest, there were 198 grade-8 male responses but only 24 posttest responses from these same males.

In the second year, 2004-05, the issue of low response in posttest was addressed by including the option of responding to the surveys online. The surveys were posted at a website. The link was provided to teachers with instructions for paper and pencil completion or electronic submission. The researcher then collected and analysed all matched pre and posttest responses from grade-8 students. There was also curiosity expressed by participants as to how females responded on the surveys, therefore, in 2004-05, the female responses were also analysed. Consequently, in this thesis, the demographic data are presented from 2003-04 and 2004-05 but the research data are for 2004-05 only.

Table 3.5 Ethnic distribution of middle grades students in number and percentages for SECME program and District percentage for 2003-04 and 2004-05

	SECME number and percentage					District percentages only		
2003-04	Number	African American	Hispanic	White		African American	Hispanic	White
6	132	64 (48%)	50 (38%)	9 (7%)		30%	58%	9%
7	163	35 (21%)	97(60%)	19 (12%)		29%	59%	10%
8	203	27 (13%)	140 (69%)	22 (11%)		28%	60%	10%
Total	498	126 (25%)	287 (58%)	50 (10%)	Average	29%	59%	10%
2004-05								
6	678	145 (21%)	254 (37%)	242 (36%)		29%	59%	9%
7	341	89 (26%)	158 (46%)	82 (24%)		29%	59%	9%
8	259	82 (32%)	131 (51%)	30 (12%)		28%	60%	9%
Total	1,278	316 (25%)	543 (42%)	354 (28%)		28%	60%	10%

Source: Sanjurjo 2005

Table 3.6 Number of middle schools in the district and SECME for 2003-04 and 2004-05

	Number of schools	
	District	SECME
2003-04	54	25
2004-05	54	27

Source: Sanjurjo 2005

The sample size in 2004-05 consisted of 129 grade-8 SECME and non-SECME students (age from 11-14 years), from which the number of African-American, Hispanic American and White students were determined. The 129 students who voluntarily responded to the questionnaires were attending middle schools that housed grades 6-8. All schools were co-educational or heterogeneously mixed. Note that the non-SECME students were classmates of the SECME students.

From the 27 middle schools with a SECME program, a smaller group, purposefully identified, was used for case studies. Students were representative of their peers in schools across the district. The duration of individual students' involvement with

SECME was identified as new (less than one year), intermediate, or veteran (more than two years). Of the three active middle school SECME programs used as case studies, one school represented a predominantly African-American male enrolment in SECME, the second was a school with no African-American males participating in the program, and the third had a balanced mixture. Special attention was given to the teachers' race and gender at all three schools. Purposeful samplings (Anderson, 1998) were conducted with the schools involved. Students shared similar characteristics in order that fewer variables would interfere with the analysis of data.

There were 38 SECME students each of whom was often recruited from the identified school coordinator's classroom. Schools made general public announcements and posted notifications of club activities. In addition to their regular classes, the SECME student would typically be involved in: 1) participating in school-site activities; 2) competing at school-site and district competitions; 3) attending Saturday engineering design seminars; and/or 4) visiting engineering/technical worksites. Grade 8 students were selected for this study because in this grade students were required to take the state FCAT science examination and the research sought to use this data to answer the research questions. The students completed FCAT Mathematics assessment in grades 6-8

There were 91 students who agreed to respond to the questionnaires also received information via the schools' general announcements. These students were in the same schools and the same grade-8 classes as the SECME students, attended the same lessons but were not involved in the SECME activities. However, these non-SECME students may have been involved in other science activities that were not reported.

3.4.3 Case Study Sites

The demographics and descriptions of the three schools targeted for the case study are described below. Each of the schools had an effective SECME program.

School A: The administrative leader at this school site was an African-American male. The school, located in the northwest area of the district, was established in 1975 with capacity for 1,383 students, and had a 111% utilisation; an indication that the school was slightly over capacity. There were no magnet, community, or adult school programs available. There were 82.7% of students on free/reduced lunch, reflective of a large student population in the low socioeconomic status. The student enrolment was 49% African-American, 46% Hispanic, and 4% White. The teacher ethnic breakdown was 47% African-American, 18% Hispanic, and 31% White with a gender distribution of 62% female and 38% male. The SECME Leader was an African-American male. Primarily, gifted minorities were involved in the program. A secondary math-focused SECME program sponsored by a College of Engineering at a state university was introduced to the school with direct support from the university for at least three years and self-sustaining, thereafter.

School B: The administrative leader at this school site was an African-American Female. The school, located in the northwest area of the district, was established in 1959 with a program capacity for 1,341 students, and had a 94% utilisation, an indication that the school was not occupied to capacity. There were no magnet, community, or adult school programs available at this school. There were 86.1% of students on free/reduced lunch, reflective of a large student population in the low socioeconomic status. The student membership was 87% African-American, 12% Hispanic, and 1% White. The teacher ethnic breakdown was 49% African-American, 13% Hispanic, and 33% White with a gender distribution of 67% female and 33% male. The SECME Leader was a White Female who frequently held activities for parents to showcase student achievement.

School C: The administrative leader at this school site was an Asian Female. The school, located in the southwest area of the district, was established in 1956 with capacity for 892 students, with 136% utilisation, an indication of overcrowding. There was a visual and performing arts magnet program and community school program at the school-site. There was no adult school program available and 49.1% of students on free/reduced lunch. The student membership was 20% African-American, 59% Hispanic, and 18% White. The teacher ethnic breakdown was 24% African-American, 36% Hispanic, and 40% White with a gender breakdown of 67% female and 33% male. There were no African-American students participating in the SECME program.

3.4.4 The SECME teachers involved in the study

For the most part, SECME teachers self-selected their involvement in the program. Initially, they may have been selected by the school's administration to attend informational sessions such as the mini-conference; however, the ones that committed to and remained involved in the program did so voluntarily. The lead teacher of the program was typically a classroom teacher. Many times that person held other leadership positions, such as department chairperson for his/her curriculum area, which was typically mathematics or science. Some teacher coordinators were paid a club stipend of $500 a year, while others did not receive any remuneration. The extra-curricular responsibilities of the coordinator varied from school to school. Ideally, the school-site coordinator would be responsible for the following:

- Encouraging and recruiting students to participate in the program at the school-site and District sponsored events;
- Providing competition opportunities at the school-site in preparation for the District Olympiad;
- Meeting with students regularly;
- Communicating with the District office;
- Collecting student information and submitting it to the District and national office;
- Registering as a SECME school with the District and National SECME offices;
- Encouraging parental participation; and
- Establishing a SECME team at the school site comprised of teachers, administrators and support staff.

3.5 The Design of the Intervention Program

SECME was designed as an intervention program to address the achievement gap and exposure of minority students to engineering through precollege experiences that integrated mathematics, science and technology. The program was coordinated from the District office and consisted of several components for the engagement of and interaction among teachers, students, parents and community partners. The District office was the liaison between the community partners and the schools and the national SECME office and the schools.

The SECME program consisted of several hands-on precollege engineering activities for students, parents, and teachers that were intended to be engaging to participants. Students were provided opportunities to visit engineering worksites and colleges. Teachers and administrators were invited to participate in professional development workshops and institutes that provided participants with current research on student achievement and practices for increasing minority student motivation in mathematics, science, engineering, and technology.

Furthermore, students, parents and teachers attended SECME Saturday Engineering Design Seminars presented on college campuses where engineers, college faculty and/or engineering students taught them mechanical and civil engineering applications for the design and construction of water-bottle rockets and model basswood bridges and mousetrap vehicles.

The intent of the program was to provide the participants with:

1) exposure to institutions of higher learning,
2) engagement in hands-on, critical thinking engineering activities,
3) networking opportunities among families, students, teachers, community partners, and K-16 educational institutions, and
4) mentoring and coaching by minority K-12 faculty, engineers, and engineering students.

The Saturday seminars also allowed students to design and construct projects such as mousetrap cars, water-bottle rockets, and basswood bridges. Each engineering project applied mathematics and science principles that were included in the classroom science curriculum. The projects could be used as the preliminary design for the final product submission to the local and/or national competition. Although the program’s main focus was to target minority students, the district could not deny program access to any public school student that expressed an interest in participating. Of special note, in the region that this research was conducted, the minority, Hispanic group, was actually the majority of the student population.

3.5.1 The SECME pre-college engineering Saturday program

A series of Saturday engineering design seminars were developed for secondary school students and their parents and teachers. Occasionally, school administrators attended. Practicing engineers representative of African-American, Hispanic and white ethnicities presented the historical and technical engineering perspective for the various project designs (i.e., mousetrap cars, basswood bridges, and water-bottle rockets) and the local engineering college/university partner hosted the events on their campuses. The program participation for the years 2003-04 and 2005-05 is shown in Tables 3.7 and 3.8.

Table 3.7 Middle school student, teacher and parent participation in SECME programs, 2003-04 and 2004-05

	Middle school student attendance by year			
	2003 – 2004		2004 - 2005	
SECME Event	Count	Percentage	Count	Percentage
Mousetrap car seminar	80/122	65%	139/163	85%
Bridge design seminar	67/121	55%	103/122	84%
Water-bottle rocket seminar	105/137	76%	114/129	88%
Olympiad competition			342/620	55%
	Middle school teacher attendance by year			
	2003 – 2004		2004 - 2005	
SECME Event	Count	Percentage	Count	Percentage
Mousetrap car seminar	8/20	26%	23/28	82%
Bridge design seminar	10/20	50%	12/16	75%
Water-bottle rocket seminar	12/17	70%	14/20	70%
Olympiad competition				
	Middle school parent attendance by year			
	2003 – 2004		2004 - 2005	
SECME Event	Count	Percentage	Count	Percentage
Mousetrap car seminar	12/20	60%	10/11	90%
Bridge design seminar	31/33	93%	31/39	79%
Water-bottle rocket seminar	39/44	88%	60/62	96%
Olympiad competition			31/45	68%

The breakdown of middle school participation at SECME events by percentage of district total is represented in Table 3.8.

Table 3.8 Middle school representation at SECME events 2003-04 and 2004-05

SECME Event	Middle school attendance by year			
	2003 – 2004		2004 – 2005	
	Count	Percentage of district	Count	Percentage of district
Mousetrap car seminar	10/54	18%	15/54	25%
Bridge design seminar	12/54	22%	14/54	25%
Water-bottle rocket seminar	12/54	22%	10/54	18%
Olympiad competition	20/54	37%	17/54	31%

The format for each Saturday Engineering Design Seminar began with a celebration of participants attending the event on a Saturday and preparing for their future. Students, parents, teachers and community partners were recognised and applauded. The SECME "Yes!" concluded the introductions. A sample introduction as presented at the SECME Bridge Design Seminar:

> Welcome to the SECME Bridge Seminar. You are congratulated for getting up early in the morning on a Saturday and taking charge of your future (applause). Special thanks to the teachers/coordinators for dedicating their time to working with students at school and for coming out on a Saturday (applause). We would also like to acknowledge the parents, without you, the students would not be here (applause). And special thanks to our hosts and the engineering students that will be presenting today and providing expert tips on building a winning bridge (applause). There's a special way that we show our appreciation in SECME. Everybody stand up. Raise you right hand and wave it in the air and bring it down with a closed fist and yell YES! Take your left hand wave it in the air and bring it down with a closed fist and yell YES! Now take both hands and wave them in the air and bring them down with a closed fist and yell YES! One more time. YES! YES! YES!

This introduction and program outline were done similarly at the other Saturday Engineering Design Seminars, the teacher coordinator mini-conference, the student competitions, and the awards banquet. Schools were notified of these events by email and direct mailings through school mail (Appendix D).

District SECME Mini-Conference

A SECME coordinator and teacher conference was held at a local SECME partnering college at the beginning of the school year in the month of September, during the fall school term. All participating schools K – 12 were invited to send the SECME Coordinator and/or a SECME team teacher (Appendix E). The memorandum was sent directly to the principals of all schools inviting them to start or continue the program at their schools. A copy of the memorandum was also sent to individual teachers who had participated in SECME previously. The teacher professional development, mini-conference, concept was modeled after the national 12-day summer institute on a much smaller scale. The agenda (Appendix F) allowed for teachers to collaborate and share best practices for implementing a successful program. There was also opportunity in the day's activities to provide support for each other. Engineers and/or experts presented the mathematics and science concepts addressed in each of the major SECME competition projects. Teachers designed and constructed working models of the same projects that their students would eventually complete. In this respect, the teachers worked through the same experiences that the students would encounter in their attempts at designing and constructing engineering projects.

Saturday seminars

In an effort to minimize classroom disruptions and avoid high-stakes testing time-frames for preparation and assessment administration, when teachers and students are not allowed to be taken out of the classroom, Saturday Engineering Design seminars occurred between the months of October and January. The intent of these seminars was to provide students, parents, and teachers with the opportunity to collaborate with each other and practicing engineers or engineering students on mathematics, science and engineering concepts. A description and sample schematic of each project can be found in Appendices G – I. Each project was addressed at a different seminar. There were three institutions of higher education (IHE) involved in hosting the Saturday seminars and providing engineering students as presenters or role-models. The presentation format began with an acknowledgement of the participants for their initiative to learn competitive tips that placed them ahead of their peers. The engineer would present the mathematics, engineering, and science concepts associated with designing and building either a mousetrap car, basswood bridge, or a water-bottle rocket. The seminars allowed middle and high school students, teachers, parents, and experts to work together to provide the opportunity for students to begin the initial designs of their projects that would later be entered into competition. At the school-site teachers were expected to work with students on the completion of the designs, testing, redesigning, and retesting in order to enter the end-of-the-year competition. Parents were provided the knowledge also to provide support at home. The seminars not only allowed for a competitive advantage to students, but also reinforced mathematics and science concepts learned in the classroom through real-world, project-based applications.

Competition

The culminating event of the program was the Olympiad (Appendix J). The event hosted approximately 900 participants that included students, parents, teachers and community partners. Apart from actual competitors, there were spectators that included friends and family members. There were 10 STEM events available for the middle school student participants to compete against each other. Events were judged by engineers, professors, engineering students and other community partners.

The schools paraded into the auditorium to the Olympics theme carrying their competition banners. Students, parents, teachers and community partners were welcomed and the “Olympiad” games were opened. There were a series of closed competitions and spectator-allowed competitions. The events ran concurrently. While scores were tabulated, there was an on-site engineering challenge for parents and students. Winners of individual events were announced at the closing ceremonies. All participating schools were provided with individual participant certificates. Trophies for the schools placing first through third were presented at the annual breakfast awards banquet. (Appendix K).

Breakfast awards banquet

The awards banquet was held at a hotel in a banquet facility that accommodated 400 guests. Schools winning at least one event were allotted seven complimentary tickets and had the option of purchasing additional seats. In this way, there could be at least a one-member representative, and his/her parent, from each winning team, had a school placed first through third in several team events. Conversely, schools not placing, received three complimentary tickets to be used by a teacher, student, parent combination as inspiration for the following year. Attendees were served a full-plated breakfast by waiters. A slide show presentation recapping the year's events from design seminars to competition was shown and 24-inch trophies were presented to the individual event winners and overall champions for each region within the district. The banquet recognised elementary through high school competitors, teachers, parents, community partners (university/industry) and administrators. The banquet venue was an integral part of the program, when considering the targeted underserved student population who may not have had the exposure or means to enjoy such a setting outside an athletic event.

3.6 Data Sources

Interviews, questionnaires, and observations in natural school settings were used to provide an understanding of student motivations and their responses to and interactions with teachers during SECME meetings, field trips, and SECME Saturday Engineering Design Seminars.

- Students' attitudes towards mathematics and science were evaluated through a modified Test of Science Related Attitudes (TOSRA) (Fraser, 1982) and Test of Mathematics Related Attitudes (TOMRA) in the form of pretests and posttests.
- Academic achievement was measured by the students' performance in mathematics and science classes in the form of academic grades and the Florida Comprehensive Assessment Test (FCAT) criterion-reference and norm-referenced test scores.
- Anecdotal comments were gathered from students, parents, and teachers involved in the SECME program.
- Teachers' and administrators' perceptions of the mathematics and science education of minority students were explored through questionnaires and interviews/observations.
- Students reflected on their attitudes toward minorities' achievement in science and mathematics through researcher developed questionnaires.

Table 3.9 Florida Comprehensive Assessment Test Criterion-Referenced Sunshine State Standards - mathematics average scale scores, district and state

	State	District
2004	311	298
2005	313	301

Table 3.10 Florida Comprehensive Assessment Test Criterion-Referenced Sunshine State Standards - science average scale scores, district and state

	State	District
2004	286	269
2005	291	272

Table 3.11 Florida Comprehensive Assessment Test Criterion-Reference Sunshine State Standards mathematics and science average district scale scores, by ethnicity for 2004 and 2005

	Mathematics		Science	
	2004	2005	2004	2005
African American	275	278	246	247
Hispanic	302	305	272	275
White	328	331	306	315

3.6.1 Questionnaires

Modified versions of the Test of Mathematics Related Attitudes (TOMRA) and Test of Science Related Attitudes (TOSRA) were included in a single survey document used to collect attitudinal data on students. Sample items from the modified TOMRA and TOSRA are found in Table 3.12. The entire survey can be found in Appendices B and C.

Researcher-designed questionnaires

At each SECME event, student, parent and teacher participants were asked questions that attempted to evaluate the day's event. For students, the engineering seminar questions were focused on their interest in mathematics and science, career awareness, connections to mathematics and science concepts currently taught in school and their overall rating of the event. Sample questions can be found in table 3.13. Sample questionnaires in their entirety can be found in Appendices L – N.

Table 3.12 Sample items from modified Test of Mathematics Related Attitudes (TOMRA) and Test of Science Related Attitudes (TOSRA)

Sample Modified TOMRA	
Scale description	Examples of items
Enjoyment of Mathematics Lessons	Mathematics lessons are fun.
Attitude to Mathematics Enquiry	I dislike repeating mathematics exercises to check that I get the same results.
Sample Modified TOSRA	
Scale description	Examples of items
Adoption of Scientific Attitudes	I enjoy reading about things which disagree with my previous ideas.
Enjoyment of Science Lessons	Science Lessons are fun.
Career Interest in Science	I would dislike becoming a scientist because it needs too much education.

Table 3.13 Sample questionnaires from student, teacher, and parent evaluations of SECME seminars

Some Open-Ended Questions		
Student	Teacher	Parent
Participating in SECME makes me feel:	How do seminars like these affect teachers?	"How do seminars like these affect your child?"
Overall, which ethnic group and gender, if any, do you think performs better in mathematics?	How do seminars like these affect students?	"How do seminars like these affect parents?"

3.6.2 Interviews

Students were interviewed in their after-school SECME club meetings and during engineering/technical site visits (Table 3.14). The interviews took place in a formal group setting where all students were asked the same questions and also in a more casual conversation venue on an individual basis. During the group setting, a question was posed and students were allowed to respond at will. The researcher waited to allow all students to respond, recording the gender, grade-level and ethnicity of the respondent. If all students did not respond, the question was re-directed to those who had not.

Table 3.14 Open-ended Interview questions for students in after-school SECME club meeting

Some open-ended questions
Participating in SECME makes me feel:
How can we get more students to join SECME?
What do you like best about SECME?

3.6.3 Observations at SECME activities

The middle school SECME activities that were available to students during the 2003 – 2005 school years were the engineering design seminars, middle school field trips, Olympiad of science, engineering, technology, mathematics, and artistic competitions and the awards banquet. The only event that occurred during regular school hours was the field trip to engineering/technical worksites, all other activities occurred on a Saturday.

3.7 Data collection and analysis procedures

There were three stages to the data collection. The first stage involved pre-testing students that were members and non-members of the SECME program. The second stage involved interviewing, observing and administering questionnaires to parents, students and teachers of SECME students. The third stage was to post-test the SECME members and non-members at participating middle schools and to retrieve final mathematics and science grades and achievement test scores for SECME and non-SECME students from the District student academic database.

The research was conducted by inviting all public schools in Miami Dade County with middle school students to participate (i.e., grades 6–8). From the 54 schools invited to participate, only 10 responded. Three schools declined for several reasons, one citing that the school did not have a SECME program, another not believing that students would return the survey permission form, and the last indicating that there was a negative incident that occurred in connection with another researcher just a few months prior to the request.

After principals agreed to participate, the pre-tests were delivered to 14 schools with test administration instructions to the SECME teacher or the principal for those schools that did not have a SECME program. The administration of the test had been planned to occur at basically the same time of the day, at the start of the school day, being administered by the Language Arts or other teacher that was not a mathematics or science subject area instructor. However, that was not the final outcome, because schools in the district were able to manage themselves and adjust their school schedule to meet the needs of their population. This meant that all middle schools were not necessarily functioning on the same daily schedule for classes or even school start-up time. Traditionally, middle schools began the day with a homeroom and advisement period which lasted approximately 25 minutes. In the case of a couple of schools, the advisement period was moved to mid-day during a regular class period. Also, some Language Arts teachers did not have an advisement class period.

Another setback occurred when the teachers did not distribute nor return the posttest surveys. Some responded that they got confused as to which students took the surveys initially, and others indicated that it was the end of the year and that it just slipped their mind or got away from them. By nature, teaching is difficult. Being able to complete a standard curriculum and ensure that all students are successful in itself is difficult to accomplish. Often times, extracurricular responsibilities take a "back-seat" to meet the central requirements of teaching and learning, therefore, the researcher to collect additional data on student attitudes, through an alternate method. Posttest surveys were then mailed to the pretest students' home addresses. This only yielded a 10 percent return in the 2003-04 academic year.

In a third attempt to collect sufficient quantitative data, the researcher redistributed pretests the following 2004-05 academic year to the SECME schools. The survey was also placed online for students to access directly. Additionally, profiles of the schools involved in the precollege engineering program were retrieved from the school district's mainframe database and were compiled. The average scale scores of the state assessment test for students in the program were compared with those who were not.

3.7.1 The Researcher's Role

The researcher's role was that of participant observer and facilitator of the District SECME activities for students and teachers involved in the program. The researcher also organised opportunities for students to visit engineering worksites and invited teachers and administrators to participate in professional development seminars addressing minority student motivation in mathematics, science, engineering and technology. The researcher managed the design, distribution and collection of the responses from the modified TOSRA/TOMRA that reflected students' perceptions of their achievement in mathematics and science. The District SECME team, teachers, administrators, and the researcher worked in collaboration to provide access to the local SECME program for students in the middle grades with particular emphasis on African-American and Hispanic American male students. The researcher also collected and compiled mathematics and science achievement data from state standardised and assessment tests. Because of the researcher's connection to the program, there was a conscious effort to avoid bias by using multiple methods of data collection. Also through the anonymous retrieval of data the use of student names and schools were avoided, and identification numbers were used instead.

3.7.2 Data Analysis

All participants at SECME events were asked to complete questionnaires. Additionally, the modified TOSRA and TOMRA were distributed to schools in hardcopy format and electronically. All data was then disaggregated by gender, grade-level and ethnicity. The data was then analysed by an external evaluator.

3.7.3 Data Identifiers

Subjects were given a unique student identification code by the school district that was known only by certain district employees, the student and his/her family. Only this code was used when data was being analysed by external parties not affiliated with the district. Gender and ethnicity were also coded by numbers. This was done to protect student identities and possible bias when analyzing the data. Neither these identifiers nor names were used when reporting the data. Case study schools were randomly assigned a letter

3.8 Ethical Issues

Research aims were clearly imparted to all participants and the school district's Office of Educational Planning and Quality Enhancement. Permission to participate was sought, with regard to students under 18 years of age, parental/guardian permission was requested. Privacy and confidentiality of participants was guaranteed in writing. Participants could opt not to participate in the study without providing any reason or receiving any penalty, at any time. Cooperation and contributions of participants were acknowledged confidentially. A letter requesting participation permission from the principal and the parent is provided in Appendices O and P.

3.9 Summary

This research study used a research framework for curriculum evaluation model that evaluated the intent of the SECME program, the implementation and the perceptions and achievement of the middle school students involved in the program. The SECME program both locally and nationally held the same intent, to increase the pool of historically and underrepresented and underserved populations of students who are achieving in science, technology, and mathematics while providing precollege engineering exposure and experiences. Ideally, a SECME school would have a team of teachers, counselors, an administrators working with students and parents as an enrichment program after-school and integrated as part of the classroom curriculum. Schools would host in-house science, technology, engineering, and mathematics (STEM) competitions in preparation for the district sponsored Olympiad.

The research design incorporated a triangulation method through the use of pre- and posttest surveys using the modified Test of Science Related Attitudes (TOSRA) and Test of Mathematics Related Attitudes (TOMRA), researcher-developed questionnaires, and observations. Academic achievement would be determined by the state administered Florida Comprehensive Assessment Test (FCAT). The aim of the study was to evaluate the presence and participation of middle school minority students in a precollege engineering program by analysis of the intent of the program, its implementation and the actual program outcomes.

The setting of the study took place in an urban public school district in the southeast section of the United States of America (USA). Of important note, this was the fourth largest school district in the USA. It was also atypical of the ethnic distribution for the rest of the nation. The minority group actually represented the majority of the population of the district.

The study took place over a two-year period and only sampled students from heterogeneously-mixed or co-educational middle school environments. However, due the low participation posttest data in the 2003-04 academic year only the data from 2004-05 academic year are reported. The participants in this study were from 10 of the 54 middle schools in the district. More in-depth case studies were conducted with three of the schools. The SECME student was typically involved in several or all of the following activities: participating in school-site engineering activities, competing at school-site and district competitions, attending Saturday engineering design seminars, and or visiting engineering/technical worksites. The schools involved in the case study were purposefully selected for their diverse representations of student populations across the district.

The SECME teachers that led the program at their school-sites were called SECME Coordinators and their responsibilities included: encouraging and recruiting students to participate in the program at the school-site and at District sponsored events; providing competition opportunities at the school-site in preparation for the District Olympiad; meeting with students regularly; communicating with the District office; collecting student information and submit to the District and national office; registering as a SECME school with the District and National SECME offices; encouraging parental participation; and establishing a SECME team at the school site comprised of teachers, administrators and support staff. SECME was designed as an intervention program to address the academic achievement gap and provide minority students with exposure to precollege engineering activities that incorporated science, technology, engineering and mathematics (STEM) concepts. The researcher managed the program at the district or central office level and implemented this research study to examine the intent of the SECME program.

CHAPTER 4

QUANTITATIVE RESULTS

SECME makes me feel like I'm part of the world. It makes me feel like a scientist even though I don't want to be one when I grow up. I feel on top of the world and smart. I like SECME very much cause it feels like I have invented something new and important. (African-American female, grade 8, new SECME student)

4.0 Overview

This chapter reports on the results of the various instruments used to collect qualitative and quantitative data on student, teacher, and parent attitudes towards middle grade student achievement in science and mathematics along with the SECME program impact on students and teachers. The chapter is divided into five sections. Sections 4.1–4.4 address research questions one to four. The last section summarizes the findings of this chapter.

4.1 Response to Research Question 1: *What is the intention of the SECME program?*

SECME, formerly the Southeastern Consortium for Minorities in Engineering, is an alliance of university/college, industry, government, and school district partnerships that provide teacher preparation and motivation to increase the successful participation of underrepresented students in science, technology, engineering, and mathematics (STEM) postsecondary education and eventually STEM-focused careers. As delineated in Chapter 3, this should be accomplished through professional development, a series of hands-on activities and competitions for students, and collaborations with higher education and industry partners.

4.2 Response to Research Question 2*: How is the SECME program implemented across the District?*

In the school district involved in this study, SECME is coordinated and managed at the district level from central office through the Division of Mathematics and Science Education. There is a staff member assigned to the program who is selected for his/her displayed passion and dedication to encourage underserved and underrepresented student populations to participate in STEM activities, while also serving as a role model and effective communicator with program partners. That person's responsibilities are to coordinate STEM activities and competitions for all the schools in the district to participate, link to the national parent organization, disseminate program information to schools, solicit funding, recruit and support school involvement and act as liaison to industry and university partners.

At the school-site level, there is a designated SECME Coordinator who manages the program at the school-site level by forming an interdisciplinary team of teachers who recruit and encourage student and parent participation in school-site and district activities and the eventual participation in local and national competitions. The various school programs are implemented as after-school extra-curricular activities, integrated into classroom curriculum, or a combination of both methods. There are no set criteria for implementation. All schools in the district have freedom to meet as frequently as deemed necessary by the school-site Coordinator. All schools, however, are expected to participate in activities that lead to student involvement in and exposure to STEM, such as the engineering design seminars and competitions conducted by the district.

As described in section 3.5, the district-managed SECME program offers a series of pre-college Saturday engineering programs for students, parents, and teachers, hosted at local engineering colleges and presented by engineers and/or engineering faculty and/or students. Schools are expected to encourage students and families to attend these events, actively engage students in pre-college engineering activities at the school site and compete in the annual SECME Olympiad of science, technology, engineering, and mathematics events.

4.3. Response to Research Question 3: *What are the reliabilities of the modified scales of TOSRA and TOMRA?*

Research questions 3, 4 and 5 address student attitudes towards science, mathematics and the relationship between attitudes and achievement in science and mathematics. The modified Test of Science Related Attitudes (TOSRA) and Test of Mathematics Related attitudes (TOMRA) were used to analyse student attitudes towards science and mathematics, respectively.

4.3.1 Scale reliabilities for modified TOSRA instrument

To respond to research question 3, a modified TOSRA was used to identify middle grade SECME and non-SECME students' attitudes towards certain aspects of science. Only items from the scales that measured Adoption of Science Attitudes, Enjoyment of Science Lessons, and Career Interest in Science were used from the TOSRA. The first issue to consider was that the modified TOSRA instrument was reliable.

The internal consistency values of the three scales of TOSRA were established by calculating Cronbach's alpha coefficients. As shown in Table 4.1, the internal consistency for the 8-item scale on the Enjoyment of Science Lessons and 7-items scale on the Career Interest in Science scales was 0.89 and 0.84, respectively, for the pretest and 0.89 and 0.84 for the posttest. The alpha coefficient for the 6-item scale on the Adoption of Scientific Attitudes was much lower at 0.52 for the pretest and 0.58 on the posttest

Table 4.1 Cronbach alpha reliability values for three scales of the Test of Science-Related Attitudes (N=129)

Scale	No. of items per scale	Pretest	Posttest
Adoption of Scientific Attitudes	6	0.52	0.58
Enjoyment of Science Lessons	8	0.89	0.89
Career Interest in Science	7	0.84	0.84

4.3.2 Scale reliabilities for modified TOSRA disaggregated by SECME and non-SECME students

The data were disaggregated by SECME and non-SECME students in order to compare both groups on the TOSRA pretest and posttest. The internal consistency reliability values are shown in Table 4.2. Reliability values for, Enjoyment of Science Lessons, and Career Interest in Science are 0.78 or above, showing high reliability. The reliability for Adoption of Science Attitudes subscale is low being between 0.51 and 0.62

Table 4.2 Internal Consistency Reliability (Cronbach Alpha Reliability) for three scales of the TOSRA for SECME students (N = 38) and non-SECME students (N = 91)

Scale	Internal Consistency Reliability					
	Pretest			Posttest		
	SECME students	Non-SECME students	Combined	SECME students	Non-SECME students	Combined
Adoption of Scientific Attitudes	0.55	0.51	0.52	0.62	0.56	0.58
Enjoyment of Science Lessons	0.78	0.91	0.89	0.88	0.92	0.89
Career Interest in Science	0.81	0.85	0.84	0.81	0.84	0.84

4.3.3 Scale reliabilities for the modified TOMRA instrument

The internal consistency values of the two scales of TOMRA were established by calculating Cronbach's alpha coefficient.

Table 4.3 Cronbach alpha reliability values for three scales of the Test of Mathematics-Related Attitudes (N = 129)

Scale	No. items per scale	Pretest	Posttest
Attitude to Mathematics Inquiry	6	0.58	0.57
Enjoyment of Mathematics Lessons	6	0.92	0.91

As shown in Table 4.3, the internal consistency for the 6-item scale of Attitude to Mathematics Inquiry and the 8-item scale on the Enjoyment of Mathematics Lessons was 0.58 and 0.92, respectively, for the pretest and 0.57 and 0.91 for the posttest. These are similar values to those of the TOSRA scales with the attitude scale being on the low side.

4.3.4 Scale reliabilities for modified TOMRA disaggregated by SECME and non-SECME students

The data were disaggregated by SECME and non-SECME students in order to compare both groups on the TOMRA pretest and posttest. The internal consistency reliability values are shown in Table 4.4. Similarly for the reliabilities for TOSRA scales, the reliability values for Enjoyment of Mathematics Lessons are 0.91 or above, showing very high reliability. The reliability for the Adoption of Mathematics Enquiry subscale is low being between 0.52 and 0.66.

Table 4.4 Internal Consistency Reliability (Cronbach Alpha Reliability) for two scales of the TOMRA for SECME students (N = 38) and non-SECME students (N = 91)

Scale	Pretest			Posttest		
	SECME students	Non-SECME students	Combined	SECME students	Non-SECME students	Combined
Attitude to Mathematics Inquiry	0.65	0.53	0.58	0.66	0.52	0.57
Enjoyment of Mathematics Lessons	0.94	0.90	0.92	0.93	0.91	0.91

4.4. Research Question 4 - What are the changes in SECME and non-SECME students' achievement in science and their attitudes towards science following their experiences in a precollege engineering program?

The modified TOSRA and the TOMRA instruments were used to identify middle grade students' attitudes towards certain aspects of science and mathematics, respectively.

4.4.1 Results of TOSRA scores for SECME and non-SECME students

Only items from the scales that measured Adoption of Science Attitudes, Enjoyment of Science Lessons, and Career Interest in Science were used from the TOSRA. As shown in Table 4.5, there were no statistically significant differences between pretest and posttest scores for either the SECME or the non-SECME students on Adoption of Science Attitudes and Career Interest in Science. However, there was a statistically significant difference ($t = 2.74$; $p<0.01$) between pretest and posttest scores for the non-SECME students on the Enjoyment of Science Lessons subscale.

Table 4.5 Descriptive statistics and paired sample comparisons of pretests and posttests on three scales of TOSRA for SECME (N=91) and non-SECME (N=38) students

Scale	SECME students		Non-SECME students		SECME students	Non-SECME students
	Pretest	Posttest	Pretest	Posttest		- t-value
Adoption of Scientific Attitudes	3.58 (0.62)	3.76 (0.56)	3.70 (0.55)	3.79 (0.55)	1.35	1.41
Enjoyment of Science Lessons	3.72 (0.68)	3.65 (0.68)	3.25 (0.86)	3.42 (0.77)	0.49	**2.74****
Career Interest in Science	3.20 (0.79)	3.14 (0.70)	2.95 (0.86)	2.86 (0.81)	0.41	1.31

* $p < 0.01$

4.4.2 What are the comparisons in science achievement and attitudes to science between ethnicities following the SECME program?

A one-way between groups multivariate analysis of variance (MANOVA) was performed to investigate ethnicity differences in the Science SSS Scales Score and three posttest attitude dimensions of the TOSRA. The three TOSRA dimensions were Adoption of Scientific Attitudes, Enjoyment of Science Lessons and Career Interest in Science.

As shown in Tables 4.6 and 4.7 for the SECME and for the Non-SECME students, there were no statistically significant differences between the four ethnic groups in terms of each of the three posttests scores for the TOSRA dimensions of Adoption of Scientific Attitudes, Enjoyment of Science Lessons and Career Interest in Science.

Table 4.6 Ethnicity differences in science achievement and posttest attitude scores on three TOSRA dimensions of SECME students (N = 38)

Outcome measures - dependent variables	Sum of Squares	Mean square	F	Significance	Partial eta squared
All dependent variables					
Science SSS Scale Score	17544.9	5848.3	2.77	0.06	0.24
Adoption of Scientific Attitudes (Posttest)	1.86	0.62	1.92	0.15	0.18
Enjoyment of Science Lessons (Posttest)	3.62	1.21	2.84	0.06	0.24
Career Interest in Science (Posttest)	2.24	0.75	1.37	0.27	0.13

As shown in Table 4.6, there were no statistically significant differences between ethnicities for the SECME students on any of the three TOSRA scales nor on the Science SSS Scale Score.

Table 4.7 Ethnicity differences in science achievement and posttest attitude scores on three TOSRA dimensions for non-SECME students (N = 92)

Outcome measures - dependent variables	Sum of Squares	Mean square	F	Significance	Partial eta squared
All dependent variables					
Science SSS Scale Score	25640.4	8546.8	**4.83**	**0.00**	0.14
Adoption of Scientific Attitudes (Posttest)	0.16	0.05	0.18	0.91	0.01
Enjoyment of Science Lessons (Posttest)	0.62	0.21	0.32	0.82	0.01
Career Interest in Science (Posttest)	0.56	0.19	0.31	0.82	0.01

As shown in Table 4.7, there were no statistically significant differences between ethnicities for the non-SECME students on any of the three TOSRA scales. There was a statistically significant difference between ethnicities on the Science SSS scale.

Table 4.8 Ethnicity comparisons of science achievement and posttest attitude scores on three TOSRA dimensions for SECME (N = 38) and non-SECME students (N = 91)

Outcome measures	Ethnicity comparison	Mean difference		Significance	
		SECME	Non-SECME	SECME	Non-SECME
Science SSS Scale Score	Hispanic American – African American	23.69	41.23	0.70	0.09
	White American – African American	21.79	**55.88**	0.92	**0.05**
	Others – African American	80.88	**68.16**	0.06	**0.01**
	Hispanic American – White American	1.90	14.64	1.00	0.77
	Others – Hispanic American	57.19	26.93	0.20	0.21
Adoption of Scientific Attitudes (Posttest)	Hispanic American – African American	0.06	0.05	1.00	1.00
	White American – African American	0.06	0.06	1.00	1.00
	Others – African American	0.77	0.04	0.21	1.00
	White American – Hispanic American	0.00	0.10	1.00	0.95
	Others – Hispanic American	0.71	0.09	0.20	0.96
Enjoyment of Science Lessons (Posttest)	African American – Hispanic American	0.28	0.20	0.80	0.94
	White American – African American	1.10	0.02	0.13	1.00
	Others – African American	0.81	0.15	0.27	0.98
	White American – Hispanic American	0.82	0.21	0.28	0.89
	Others – Hispanic American	0.53	0.04	0.56	1.00
Career Interest in Science (Posttest)	African American – Hispanic American	0.22	0.13	0.92	0.98
	White American – African American	0.80	0.29	0.48	0.89
	African American – Others	0.71	0.25	0.49	0.91
	White American – Hispanic American	0.57	0.16	0.68	0.94
	Others – Hispanic American	0.49	0.12	0.70	0.96

A Scheffé Test involving multiple comparisons between the four ethnic groups of SECME students shown in table 4.8 indicated no statistically significant differences between any of the four ethnicities on the three TOSRA scales.

A Scheffé Test involving multiple comparisons between the four ethnic groups of the non-SECME students indicated significant differences in the Science SSS Scale Score between: (1) Students of other ethnicities (M = 382.7, SD = 56.8) and African

Americans [M = 317.7, SD = 39.4; *p* < 0.01], and (2) Hispanic Americans (M = 361.2, SD = 38.0) and African Americans [M = 317.7, SD = 39.4; *p* < 0.01].

4.4.3 What are the comparisons in achievement in science and attitudes to science between males and females?

As shown in Tables 4.9 for the SECME students there were no statistically significant differences between genders on the science score but there were statistically significant differences between genders on two of the three TOSRA scales – Enjoyment of Science Lessons ($t = 3.17$; $p < 0.01$) and Career Interest in Science ($t = 2.80$; $p < 0.01$) in favour of males.

Table 4.9 Gender differences in science achievement and posttest attitude scores on three TOSRA dimensions for SECME students (N = 38) (36 males and 2 females)

Outcome measures	Mean		SD		t	Significance	eta squared
	Males	Females	Males	Females			
Science SSS Scale Score	358.96	317.75	51.06	16.21	1.58	0.13	1.09
Adoption of Scientific Attitudes (Posttest)	3.84	3.33	0.61	0.24	1.64	0.11	1.10
Enjoyment of Science Lessons (Posttest)	3.97	2.91	0.60	0.87	**3.17**	**0.00**	1.42
Career Interest in Science (Posttest)	3.39	2.39	0.66	0.73	**2.80**	**0.01**	1.44

As shown in Table 4.10 for the non- SECME students there were no statistically significant differences between genders on the science scores or any of the three TOSRA scales.

Table 4.10

Gender differences in science achievement and posttest attitude scores on three TOSRA dimensions of non-SECME students (N = 91) (37 males and 54 females)

Outcome measures	Mean		SD		t	Significance	eta squared
	Males	Females	Males	Females			
Science SSS Scale Score	367.30	350.17	37.34	48.61	1.85	0.07	0.40
Adoption of Scientific Attitudes (Posttest)	3.78	3.78	0.49	0.57	0.04	0.97	0.00
Enjoyment of Science Lessons (Posttest)	3.39	3.36	0.79	0.83	0.17	0.87	0.04
Career Interest in Science (Posttest)	2.88	2.79	0.69	0.85	0.56	0.58	0.12

4.5 Research Question 5 - ***What are the changes in SECME and non-SECME students' mathematics achievement and their attitudes towards mathematics following their experiences in a precollege engineering program?***

Based on the data in table 4.11, the differences in pretest and posttest scores on the Enjoyment of Mathematics Lesson and Attitude to Mathematics Enquiry of the Test of Mathematics-Related Attitudes (TOMRA) showed no statistically significant differences following the pre-college engineering SECME program for SECME and non-SECME students.

A possibility as to why there was not much difference between the attitudes towards science and mathematics in the pretests and posttests for both SECME and non-SECME students could have been attributed to students in the program elected to be in the program because they were interested in science and/or mathematics. As shown in Table 4.11, all pretest scores on the TOSRA and TOMRA scales are above 3.0, the central point, and in some cases such as Enjoyment of Science Lessons, at 3.72 very high.

Additionally, the students' attitudes towards enjoyment of the subjects did not change.

Table 4.11 Descriptive statistics and paired-sample comparisons of pretests and posttests on two scales – Attitude to Mathematics Inquiry and Enjoyment of Mathematics Lessons – of the TOMRA for SECME students (N = 38) and non-SECME students (91).

Scale	Mean (SD)				t-value	
	SECME students		Non-SECME students		SECME students	Non-SECME students
	Pretest	Posttest	Pretest	Posttest		
Attitude to Mathematics Inquiry	3.39(0.75)	3.64(0.66)	3.47(0.60)	3.56(0.56)	1.80	1.59
Enjoyment of Mathematics Lessons	3.34(1.18)	3.51(1.06)	3.27(0.95)	3.31(0.97)	0.97	0.52

Table 4.12 Differences in Mathematics Achievement and Posttest Attitude Scores on two TOMRA dimensions for–SECME students (N = 38) and non-SECME students (N = 91)

Outcome measures	Mean		SD		t	Significance	eta squared
	SECME	Non-SECME	SECME	Non-SECME			
FCAT SSS Mathematics Scale Score	351.89	365.06	28.35	29.77	**2.31**	**0.02**	0.46
FCAT Mathematics Achievement Level	3.63	4.03	0.91	0.73	**2.63**	**0.01**	0.48
NRT Mathematics Percentile	86.84	88.21	10.70	9.98	0.69	0.49	0.13
Attitude to Mathematics Enquiry (Posttest)	3.64	3.60	0.66	0.56	-0.75	0.46	0.07
Enjoyment of Mathematics Lessons (Posttest)	3.51	3.31	1.07	0.98	-1.04	0.30	0.19

There was a significant difference in the FCAT SSS Mathematics Scale Score between SECME students (M = 351.89, SD = 28.35) and non-SECME students (M = 365.06, SD = 29.77; t (125) = 2.314, $p < 0.05$), with a large effect size of 0.46. The difference is in favour of the non-SECME students.

There was also a significant difference in the FCAT Mathematics Achievement Level between SECME students (M = 3.63, SD = 0.91) and non-SECME students (M = 4.03, SD = 0.73; t (125) = 2.63, $p < 0.01$), as denoted by a large effect size of 0.48. The difference is in favour of the non-SECME students.

There were no significant differences in the NRT Mathematics Percentile and posttest mean scores of the Attitude to Mathematics Enquiry and the Enjoyment of Mathematics Lessons dimensions of the TOMRA between SECME and non-SECME students.

Since SECME students were exposed to practicing engineers and engaged in hands-on engineering activities an increase in mathematics and scientific attitudes and career interest were expected to be greater for students involved in SECME in comparison to those not in SECME. However, there may not have been a significant difference in the enjoyment of science lessons because SECME may have been viewed more as an extra-curricular experience rather than an enhancement opportunity for students' science classroom experiences.

4.5.1 What are the comparisons in achievement in mathematics and attitudes to mathematics between ethnicities?

With respect to the modified TOMRA, a MANOVA was performed to investigate ethnicity differences in three mathematics achievement scores and two posttest attitude dimensions of the TOMRA. The three achievement scores were the FCAT SSS Mathematics Scale Score, the FCAT Mathematics Achievement Level and the NRT Mathematics Percentile. The two TOMRA dimensions were Attitude to Mathematics Enquiry and Enjoyment of Mathematics Lessons.

As shown in Table 4.13, there were no statistically significant differences between ethnicities for the SECME students on the TOMRA scales or the Mathematics Achievement tests.

Table 4.13 Ethnicity differences in mathematics achievement and posttest attitude scores on two TOMRA dimensions of SECME students (N = 38)

Outcome measures	Sum of Squares	Mean Square	F	Significance	Partial eta squared
FCAT SSS Mathematics Scale Score (2004/05)	1889.0	629.7	0.77	0.52	0.06
FCAT Mathematics Achievement Level (2004/2005)	0.65	0.22	0.25	0.87	0.02
NRT Mathematics Percentile (2004/2005)	184.11	61.37	0.52	0.68	0.04
Attitude to Mathematics Enquiry (Posttest)	1.68	0.56	1.32	0.28	0.11
Enjoyment of Mathematics Lessons (Posttest)	2.98	0.99	0.88	0.46	0.07

As shown in Table 4.14, there was a statistically significant difference between ethnicities for the non-SECME students on the FCAT SSS Mathematics Achievement scale ($F = 3.05$; $p < 0.03$).

Table 4.14 Ethnicity differences in mathematics achievement and posttest attitude scores on two TOMRA dimensions of non-SECME students (N = 91)

Outcome measures	Sum of Squares	Mean Square	F	Significance	Partial eta squared
FCAT SSS Mathematics Scale Score (2004/05)	7490.8	2496.9	**3.05**	**0.03**	0.10
FCAT Mathematics Achievement Level (2004/2005)	3.88	1.29	2.58	0.06	0.08
NRT Mathematics Percentile (2004/2005)	178.50	59.50	0.60	0.62	0.02
Attitude to Mathematics Enquiry (Posttest)	0.31	0.10	0.32	0.81	0.01
Enjoyment of Mathematics Lessons (Posttest)	0.39	0.13	0.13	0.94	0.01

Table 4.15 Ethnicity comparisons of mathematics achievement and posttest attitude scores on two TOMRA dimensions for SECME (N = 38) and non-SECME students (N = 91)

Outcome measures	Ethnicity comparison	Mean difference		Significance	
		SECME	Non-SECME	SECME	Non-SECME
FCAT SSS Mathematics Scale Score (2004/05)	Hispanic American – African American	18.21	18.61	0.64	0.36
	White American – African American	4.92	29.22	0.99	0.16
	Others – African American	7.17	34.13	0.98	0.06
	Hispanic American – White American		10.61		0.72
	Others – Hispanic American	11.05	15.52	0.89	0.36
FCAT Mathematics Achievement Level (2004/2005)	Hispanic American – African American	0.29	0.30	0.94	0.72
	White American – African American	0.00	0.50	1.00	0.47
	Others – African American	0.17	0.76	0.99	0.10
	White American – Hispanic American	0.29	0.20	0.90	0.85
	Others – Hispanic American	0.12	0.46	1.00	0.19
NRT Mathematics Percentile (2004/2005)	African American – Hispanic American	2.71	2.32	0.98	0.94
	White American – African American	1.25	2.61	1.00	0.95
	Others – African American	4.67	5.44	0.91	0.66
	White American – Hispanic American	3.96	0.29	0.84	1.00
	Others – Hispanic American	1.95	3.13	0.99	0.78
Attitude to Mathematics Enquiry (Posttest)	African American – Hispanic American	0.03	0.10	1.00	0.97
	White American – African American	0.11	0.01	0.99	1.00
	African American – Others	0.58	0.20	0.50	0.89
	White American – Hispanic American	0.14	0.09	0.96	0.97
	Others – Hispanic American	0.61	0.10	0.31	0.95
Enjoyment of Mathematics Lessons (Posttest)	African American – Hispanic American	0.38	0.21	0.91	0.95
	White American – African American	0.08	0.13	1.00	0.99
	African American – Others	0.44	0.20	0.91	0.97
	White American – Hispanic American	0.30	0.09	0.91	0.99
	Others – Hispanic American	0.83	0.01	0.48	1.00

A Scheffé Test involving multiple comparisons between the four ethnic groups of SECME students shown in table 4.15 indicated no statistically significant differences between any of the four ethnicities on the three TOSRA scales. A Scheffé Test involving multiple comparisons between the four ethnic groups of non-SECME students indicated no statistically significant differences between the any of the four ethnicities between White American – African American and between Others and African American.

4.5.2 What is the comparison in posttest scores for achievement in mathematics and attitudes to mathematics between males and females?

An independent samples t-test was performed to investigate differences in the outcomes of the three mathematics achievement measures and the two posttest attitude dimensions of the TOMRA for male and female SECME and male and female non-SECME students. As shown in Table 4.16 for SECME students and in Table 4.17 for non-SECME students, respectively, there were no statistically significant differences on any measure.

Table 4.16 Gender differences in mathematics achievement and posttest attitude scores on two TOMRA dimensions of SECME students (N = 38) (36 males and 2 females)

Outcome measures	Mean		SD		t	Significance	eta squared
	Males	Females	Males	Females			
FCAT SSS Mathematics Scale Score	351.89	352.00	29.15	0.00	0.01	1.00	0.01
FCAT Mathematics Achievement Level	3.61	4.00	0.93	0.00	0.58	0.57	0.59
NRT Mathematics Percentile	86.67	90.00	10.81	11.31	0.42	0.67	0.30
Attitude to Mathematics Enquiry (Posttest)	3.68	3.00	0.66	0.00	1.44	0.16	1.46
Enjoyment of Mathematics Lessons (Posttest)	3.56	2.67	1.07	0.24	1.17	0.25	1.15

Table 4.17 Gender differences in mathematics achievement and posttest attitude scores on two TOMRA dimensions of non-SECME students (N = 91) (37 males and 54 females)

Outcome measures	Mean		SD		t	Significance	eta squared
	Males	Females	Males	Females			
FCAT SSS Mathematics Scale Score	371.67	360.59	27.06	30.62	1.76	0.08	0.38
FCAT Mathematics Achievement Level	4.11	3.98	0.67	0.77	0.83	0.41	0.18
NRT Mathematics Percentile	90.36	86.70	7.27	11.19	1.73	0.09	0.39
Attitude to Mathematics Enquiry (Posttest)	3.62	3.52	0.46	0.62	0.83	0.41	0.18
Enjoyment of Mathematics Lessons (Posttest)	3.27	3.34	0.91	1.02	0.35	0.73	0.07

4.6 Research Question 6 - ***What is the relationship between attitudes towards science/mathematics and academic achievement following their experiences in a pre-college engineering program?***

As shown in Table 4.18, with one exception, there were no statistically significant relationships between students' scores on the three attitude scales of TOSRA and their achievement on any of the four cognitive measures. The correlation showing significance (r = -0.23) was between Enjoyment of Science Lessons and The FCAT Sunshine State Standards Mathematics scores for the non-SECME which was negatively correlated. In other words, these students who did not enjoy science lessons scored higher on the FCAT mathematics test, and vice versa.

Table 4.18 Correlations of posttest means scores of three scales of TOSRA with four academic achievement scores for SECME students (N = 38) and non-SECME students (N = 91)

	FCAT SSS Scale Score Math 2004/05		FCAT Math Achievement Level 2004/05		NRT Math Percentile 2004/05		Science SSS Scale Score 2004/05	
	SECME	Non-SECME	SECME	Non-SECME	SECME	Non-SECME	SECME	Non-SECME
Adoption of Scientific Attitudes	0.09	0.06	0.08	-0.05	0.21	0.11	0.29	0.20
Enjoyment of Science Lessons	0.10	-0.23*	0.02	-0.18	0.10	-0.07	0.33	-0.04
Career Interest in Science	-0.02	-0.17	-0.06	-0.16	-0.02	-0.08	0.12	0.05

*$p < 0.05$

Table 4.19 Correlations of posttest means scores of two scales of TOMRA with four academic achievement scores for SECME students (N = 38) and non-SECME students (N = 91)

	FCAT SSS Scale Score Math 2004/05		FCAT Math Achievement Level 2004/05		NRT Math Percentile 2004/05		Science SSS Scale Score 2004/05	
	SECME	Non-SECME	SECME	Non-SECME	SECME	Non-SECME	SECME	Non-SECME
Attitude to Mathematics Enquiry (Posttest)	0.31	0.11	0.25	0.11	0.46**	0.17	0.24	0.03
Enjoyment of Mathematics Lessons (Posttest)	0.35*	0.33**	0.32	0.33**	0.50**	0.29**	0.16	0.11

**$p < 0.01$ *$p < 0.05$

As shown in Table 4.19, for the SECME students Enjoyment of Mathematics Lessons correlated positively with FCAT SSS Mathematics scores (r = 0.35, P < .05) and the NRT Math Percentile (r = 0.50, p < 0.01). For the non-SECME students there were statistically significant relationships between students' scores on Enjoyment of Mathematics Lessons and each of the Mathematics achievement measures at p < 0.01.

Table 4.20 Simple correlation and multiple regression posttest analysis for associations between four academic achievement scores and three dimensions of the TOSRA for SECME students (N = 38) and non-SECME students (N = 91)

Scale	FCATT SSS Scale Score				FCAT Math Achievement Level				NRT Math Percentile				Science SSS Scale Score			
	SECME Students		Non-SECME Students		SECME Students		Non-SECME Students		SECME Students		Non-SECME Students		SECME Students		Non-SECME Students	
	r	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β
Adoption of Scientific Attitudes	0.01	0.12	0.08 -	0.21 -	0.10	0.33 -	0.01	0.08	0.01	0.03 -	0.16 -	0.21 -	0.29	0.22 -	0.20 -	**0.26*** -
Enjoyment of Science Lessons	0.16	0.17	**0.21***	0.23	0.01	0.34	0.17	0.08	0.04	0.07	0.03	0.06	0.29	0.33	0.00	0.21
Career Interest in Science	0.14	0.07	**0.21***	0.11	0.08	0.31	**0.22***	0.19	0.01	0.03 -	0.08	0.10	0.10	0.21	0.06	0.14
R^2	0.04		0.09		0.03		0.06		0.00		0.04		0.14		0.06	

*$p < 0.05$

Table 4.21 Simple correlation and multiple regression posttest analysis for associations between four academic achievement scores and two dimensions of the TOMRA for SECME students (N = 38) and non-SECME students (N = 91)

Scale	FCATT SSS Scale Score Math				FCAT Math Achievement Level				NRT Math Percentile				Science SSS Scale Score			
	SECME Students		Non-SECME Students		SECME Students		Non-SECME Students		SECME Students		Non-SECME Students		SECME Students		Non-SECME Students	
	r	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β	*r*	β
Attitude to Mathematics Inquiry	0.42	0.28	0.10	-0.08	0.32	0.14	0.10	-0.09	**0.46****	0.28	0.19	0.04	0.23	0.31	0.06	0.00
Enjoyment of Mathematics Lessons	0.40	0.17	**0.32****	**0.36****	0.33	0.22	**0.34****	**0.39****	**0.45***	0.22	**0.32****	0.30*	0.14	-0.10	0.13	0.13
R^2	0.19		0.11		0.12		0.12		0.23		0.10		0.06		0.02	

$**p < 0.01$ $*p < 0.05$

Based on the data in Table 4.20, for the non-SECME students, there were statistically significant positive correlations between the Enjoyment of Science Lessons with the FCAT Mathematics Scale score ($r = 0.21$, $p < 0.05$) as well as Career Interest in Science with the FCAT Mathematics Scale score ($r = 0.21$, $p < 0.05$) and FCAT Mathematics Achievement Level ($r = 0.22$, $p < 0.05$). The regression coefficient shows that for non-SECME students, the Adoption of Scientific Attitudes is a significant independent predictor of Science Sunshine State Standards Scale (Beta = .26, $p < 0.05$).

Based on the data in Table 4.22, for the SECME students, there were statistically significant positive correlations between Attitudes to Mathematics Inquiry with the FCAT Mathematics Scale score ($r = 0.42$; $p < 0.05$) as well and Enjoyment of Mathematics Lessons with the FCAT Mathematics Scale score ($r = 0.40$, $p < 0.05$) and the NRT Mathematics Percentile($r = 0.45$, $p < 0.05$).

For the non- SECME students, there were statistically significant positive correlations between Enjoyment of Mathematics Lessons with the FCAT Mathematics Scale score ($r = 032$: $p < 0.01$), the FCAT Mathematics Achievement Level ($r = 0.34$; $p< 0.01$) and NRT Mathematics Percentile($r = 0.32$, $p < 0.01$). The regression coefficient shows that for non-SECME students, the Enjoyment of Mathematics Lessons is a significant independent predictor of FCAT Science Sunshine State Standards Scale (Beta = .36, $p < 0.01$).

4.7 Summary of quantitative data

The intent of the SECME program is to prepare and motivate underrepresented students to enter and successfully complete postsecondary studies in science, technology, engineering, and mathematics (Research Question 1). A SECME coordinator and/or team of teachers were designated at the school-site to manage the program and encourage these underrepresented students and their families to participate in the district sponsored Saturday engineering activities and competition (2).

The modified Test of Science Related Attitudes (TOSRA) and Test of Mathematics Related Attitudes (TOMRA) were used to analyse SECME and non-SECME middle grades students' attitudes towards science and mathematics, respectively (Research Question 3). The criterion-referenced test, the Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards (SSS), that is given by the State where the study took place, along with the FCAT Norm Referenced Test (NRT), were used to ascertain and compare student achievement.

The internal consistency reliability of the three scales of the TOSRA and the two scales of the TOMRA were established by calculating the Cronbach's alpha coefficients. For the modified TOSRA, the reliability values for the Enjoyment of Science Lessons and Career Interest in Science showed high reliability whereas the Adoption of Science Attitudes subscale had a relatively low reliability. With respect to the modified TOMRA, the attitude scale, Attitude to Mathematics Inquiry, was low while the Enjoyment of Mathematics reliability was high. There was a statistical significant difference between the pretest and posttest scores for the non-SECME students on the Enjoyment of Science Lessons subscale but not for the SECME students (Research Question 3).

A comparison in science achievement and attitudes to science between ethnicities for SECME and non-SECME students indicated no significant difference between the four ethnic groups on each TOSRA subscale posttest attitudinal score. There were, however, statistical differences for the non-SECME students between ethnicities on the FCAT Science Sunshine State Standard (SSS) scale. There were statistically significant differences between White American – African American and between Others and African American students. No such difference was evident in the SECME group.

For gender comparisons, there were no statistically significant differences between genders on the science achievement scores. However, there were statistically significant differences between genders on two of the three TOSRA scales, Adoption of Scientific Attitudes and Enjoyment of Science Lessons, in favour of SECME males. In contrast, there were no statistically significant differences in science achievement and posttest attitudinal scores on any of the three TOSRA scales for the non-SECME students (Research Question 4).

Similarly, both the SECME and non-SECME students demonstrated no statistically significant differences on the attitudinal scales, Enjoyment of Mathematics Lessons and Attitude to Mathematics Enquiry, of the modified TOMRA. With respect to the FCAT SSS Mathematics Scale Score and Achievement Level, however, there was a significant difference between SECME and non-SECME students, in favour of the non-SECME students. A gender comparison revealed that there was a statistically significant difference between SECME and non-SECME male student performance on the FCAT SSS Mathematics and the FCAT Mathematics Achievement Level, in favour of the non-SECME male. However, there were no significant differences in the NRT Mathematics percentile and posttest scores of the Attitude to Mathematics Enquiry and the Enjoyment of Mathematics lessons dimensions of the TOMRA for these same groups of males. Interestingly, the females showed no significant differences in the outcomes for the attitudinal or achievement assessments (Research Question 5).

Although there was no statistically significant relationship between students' scores on the three science attitudinal scales and their achievement on any of the four cognitive measures, it was found that Adoption of Scientific Attitudes is a significant, independent predictor of FCAT Mathematics Achievement Level.

CHAPTER 5
QUALITATIVE RESULTS

5.0 Overview

This chapter presents the results from the case study schools and deals with SECME students only. The chapter is divided into five sections. Section 5.1 presents Reflections on Minority Achievement in Mathematics and Science; Section 5.2 describes the Case Studies Observations and Reflections; Section 5.3 discusses the SECME Coordinator/Teacher Program Comments; Section 5.4 presents the SECME Student Program Comments; and Section 5.5 is a Summary of the Chapter.

5.1 Response to Research Question 7: Reflections on Minority Achievement in Science and Mathematics

The following questions and responses were derived from researcher-developed questionnaires between 2003 and 2005. Students, parents and teachers attended these events voluntarily. All participants engaged in the same activities, cooperatively, in mixed groups during the events. The events included Saturday Engineering Design Seminars for teachers, parents and students, engineering and technical site visits for teachers and students, teacher professional development workshops, and the annual awards breakfast banquet.

The Saturday engineering seminars lasted three hours and were hosted at partnering college/university campuses. The presenters were practicing engineers and/or engineering students. The day opened with a welcome and the “SECME Yes!” participant cheer followed by the technical presentation of the historical perspective and mathematics and science concepts that would be explored through the design process of the products created. At these seminars, students, teachers and parents worked in teams to learn and apply mathematics and science concepts as related to the engineering projects that were constructed during the seminar. The product completed at the seminar provided a foundation for the final project that would be submitted at the school-site and eventually at the District competition. Everyone was exposed to the same introduction and worked together to complete the project design, and there was ample opportunity for the participants to communicate and network over the course of the three-hour session**.** SECME students stated that they have an interest in attending school-related activities beyond the school-day, as evidenced by their attendance at these Saturday seminars.[moved this from 5.1.1]

The following responses addressed **Research Question 7. What are students' parents', teachers' and researches' reflections on minorities' achievement in science and mathematics?**

5.1.1 Student perceptions

An understanding of the students' preconceived perceptions of minority achievement would be of value. Therefore, a random sampling of student responses was collected.

Table 5.1 Some middle school male student responses to the question: Overall, which ethnic group and gender, if any, do you think performs better in mathematics? (N=7)

		Better Ethnicity in Mathematics			Better Gender in Mathematics		Unsure
Ethnicity	SECME Status	AA	H	W	Female	Male	
African-American	New			X		X	
	Veteran						
	Non-SECME						
Hispanic	New						
	Veteran			XX		XX	X
	Non-SECME		X			X	
White	New			XX	X	X	
	Veteran						
	Non-SECME						

Additionally, since the program was comprised mostly of minorities, one would expect that participating in a program that has a mission and goal of encouraging minorities to persist in mathematics and science, there would be an association that minorities and females would be seen as able to excel in mathematics and science and the stereotypes of the ethnic majority surpassing all other ethnic subgroups would be squelched. Table 5.1 seems to depict student perceptions to the contrary.

Supporting this high self-perception expectation was the fact that the minority represented the ethnic majority in the region where this research occurred. With the concerns expressed in Chapter 2 that minority male students drop out of school earlier than females and the stereotypes and stigma associated with minority males' academic ambition and achievement, Tables 5.1–5.3 address only male respondents.

As delineated in Table 5.1, a veteran Hispanic SECME student indicated that SECME males performed better in mathematics. African American male SECME students consistently indicated that males were the better performing gender in mathematics and science. However, they were unsure as to which ethnic group performed better. The Hispanic American SECME students were positive in their comments that Whites, Asians and, occasionally, Hispanics performed better. The majority of the responses favored white males for performing better in mathematics. Interestingly, when the same respondents were asked which gender performed better in science, the majority indicated females. This indicated to the researcher that even in this program that targets minorities; in the middle grades, there are still doubts as to their (male minorities') achievements in mathematics and science exceeding the majority ethnic group.

Table 5.2 Some veteran SECME students' responses to the question, "Why do you think that some students perform better in mathematics than other students?"

Ethnicity	Veteran SECME Students' Responses			
Hispanic	"Some study more, some pay more attention"	"Because math probably is there [their] strength in school"	"cause their [they're] smarter"	"because different ethnic groups behave differently"

Table 5.2 indicates that some middle school minority male SECME students have determined that their success in mathematics is dependent on a genetic predisposition of being smarter or the right ethnicity.

5.1.2 Parent Perceptions

The gender and ethnic breakdown of the parents of middle school males who attended a sampled SECME engineering seminar are indicated in Table 5.3. These parents' responses to gender and ethnic performance in science and mathematics are compiled in Table 5.4.

Table 5.3 Gender and ethnicity of some parents of middle school males attending a sampled SECME Saturday Engineering Design Seminars

	Gender			
Ethnicity	Female	Male	Unknown	Total
Black				0
Hispanic	2	6	1	9
White		1		1
Total	2	7	1	10

As indicated in Table 5.3, the level of participation by African American parents of middle grades male students is significantly lower than Hispanic American parents. In fact, at the event sampled in this study, they were non-existent. If this correlated to the ethnic demographics of the school district, White parents would still represent 10 percent of the population of parents in attendance and Black parents did not represent 29%. Although just a sampling of the seminars offered, this was representative of the typical participation at the Saturday program offerings. This is unfortunate when one considers the impact that these seminars can have on parents, as described by one of the attendees in a comment emailed to the District program coordinator in the central office.

> I wanted to let you all know that today's was a wonderful opportunity for students and parents to demystify the subject of bottle rockets. We came as a family and my 11th grader…had previously attended this seminar while in 6th grade but my current 6th grader is a novice and is on his school's team this year. By the time my 6th grader launched his rocket my husband along with both children were so engrossed in the competition that the drizzle that caused [the engineering partner] to don his jacket did not dampen their enthusiasm. My husband who has never attended any of these competitions was smitten by these rockets when he witnessed the first one launched. I need to add that my husband does not know the correct end of a hammer, so this was a

> thrill for me to see his interest….[my son] was pleased with his first launch. What confidence he gained today! (SECME Parent, Jan. 31, 2004; 9:10 p.m.)

Table 5.4 Parents of male SECME students' responses to questionnaire on perceptions of gender and ethnicity performance in mathematics and science

	Some Parent Responses		
	Female	Male	Unknown
"How do seminars like these affect your child?"	"opens curiosity" – *Hispanic* "Instil curiosity"	"very impacting, gives opportunities, increased self- confidence" – *Hispanic* "provides good learning environment" –*White*	
"How do seminars like these affect parents?"	"Can take lesson home for further application"	"by helping motivate" – *Hispanic* "we learn too" –*Hispanic* "strengthen bondings parent – children" –*Hispanic*	"helps us help our children" – *Hispanic*
"Which gender, if either, do you believe performs better in mathematics (males or females)?"			majority indicated males
"Which gender, if either, do you believe performs better in mathematics (males or females)?"			majority indicated males
"Do you believe that certain ethnic groups perform better in science…mathematics?"	"no" – *1 respondent*	"no" – *6 respondents* "I'm not going to answer racist & sexist" – *Hispanic*	"no" – *1 respondent*

These were all the responses from male SECME student parents in attendance at a Saturday seminar and were typical of parent responses.

5.1.3 Teacher perceptions

In a survey administered at the annual SECME awards banquet honoring student, parent, teacher and administrator accomplishments, 11 of the 14 female middle grade teachers in attendance indicated that the SECME program addressed the needs of minority males to be successful in science, mathematics, and precollege engineering. The only male in attendance, a White male, at the event placed a question mark for his answer, while one female teacher commented “I feel all students male/female should be addressed equally.” Additional comments were as follows:

> Yes, every seminar that they go to emphasizes the importance of the topic mentioned above (Hispanic Female).

There were no documented comments from African American male coordinators. This could indicate that at the middle school level, the teachers working with the SECME students overwhelmingly are typically female and Hispanic. However, there may be other circumstances leading to African American male coordinators not responding. If the former is correct, this does not allow for African American male students to be exposed to the necessary role-models or mentors that the review of literature indicated that was essential to the success of the African American male.

When the teachers were asked if the SECME program addressed the needs of minority females, the responses generated by the female SECME teachers were as follows:

> Females are as important as males representing these [mathematics, science, engineering and/or technology] careers.
>
> I feel all students male/female should be addressed equally.
>
> Yes it helps the students to know how important their presence is, to be involved.

Some female SECME Coordinators indicated that there were some improvements needed in the program to fully address minority female needs:

> More activities are needed to get them [minority females] interested.
>
> Most minority females and males need the emotional support in order for them to be free enough to study.
>
> There should be something for female/parents to attend so they may feel more comfortable allowing their daughters to attend.
>
> Yes. The SECME RISE program should return.

The last comment referred to a middle school program, SECME Girls RISE – Raising Interest in Science and Engineering, that was implemented in the school district for four years, from 1998 to 2001. The program was a grant funded collaboration among the District, national SECME program, the Museum of Science, and the National Science Foundation. The grant targeted a different cohort of middle school girls participating in the SECME program each year. The girls attended Saturday programs, participated in SECME activities, and were paid to complete a summer institute. Both sets of activities were gender exclusive, females only. The girls worked with student mentors and female engineers, and the program was received positively by teachers and students.

With respect to the program meeting the needs of minority males, the SECME Coordinators' responses were as follows:

> Yes. Every seminar that they go to emphasises the importance of the topic mentioned above [mathematics, science, engineering and/or technology].
>
> Encourage anyone who shows interest.

When asked, "Does SECME provide support/encouragement for minority and underrepresented students to pursue studies and careers in mathematics, science, engineering, and/or technology?" The following responses were provided by the SECME teachers/coordinators:

> Workshops help students understand the concepts.
>
> It exposes children to ways to make dreams become reality
>
> It encourages the student.
>
> These activities motivate the students to continue studies in math, science, engineering, and tech.

5.1.4 Researcher Perceptions

Because this researcher also coordinated and managed the SECME program, personal perceptions of minority achievement have evolved over the years. As an islander who was raised in a country and family that did not view race as dictating one's ability to achieve academically, especially in the science, engineering, and/or mathematics fields, it has been difficult to relate to that trend of thought. My family and homeland have produced successful male and female minority scientists, mathematicians and engineers. In actuality, those were careers that were lauded and pursued along with high academic achievement. Therefore, even into middle adulthood, I believed that, like me, all students could achieve their desires and dreams and were provided the opportunities for that success. However, the SECME program has afforded a glimpse into the realities that many minorities in this country face. The opportunity to network with and observe the national predicament of how underserved and unrepresented minorities in this country are in the STEM fields, has truly been an awakening.

The minority student is often overlooked and academic achievement comes second to athletics, and in many instances, misconduct, especially for the males. Although, females continue to be underrepresented, there has been a concerted effort over the past couple of decades to address this disparity and there have been notable improvements, especially in the school district involved in this study. The SECME Girls RISE program was evidence of this. There were many success stories of girls from the program pursuing postsecondary studies in engineering and graduating in the field. Likewise, because the school district was predominately Hispanic American, there were many similar academic successes for both males and females in this ethnic group. The district was even home to successful and nationally recognised Hispanic serving institutions of higher education, further revealing that the one group that was still left behind was the African American male.

5.2 Case Study Schools' Observations and Reflections

Since there was some to no representation by African American students and/or their parents at the district sponsored Saturday Engineering Design Seminars, further observations were conducted by visiting three schools with active SECME programs to ascertain the level of minority participation and activities offered to the students and their families at the school-site.

5.2.1 Case study school A

The Administrative Leader, an African American male, was very proactive in recruiting and hiring other African American male teachers who would provide positive role models to the students. In a conversation with a mathematics supervisor from another state, the School A Administrative Leader made the following comments with respect to school climate and leadership support: Teachers from his school had felt that administration was not in it for the long run. There was a very high administrative turnover prior to his assignment at the school. He assured the teachers that he was there to stay. After his second year at the school, he was offered a principal position at a high school, but did not accept which made the teachers feel more secure.

The administrative leader at case study school A further indicated that the school, in 2004, was graded by the Governor of the state and given a C, "missing a B [grade] by a few points." Four years ago, at the principal's arrival, the school was given the grade of D from the state with staff feeling complacent. They felt that the grade was a true reflection of what the school was capable of achieving. The leader at School A embraced the SECME program, and was eager to be involved in any and all activities that were offered. He accompanied teachers to the national Summer Institute and made it a point to spend free-time with them at the Institute. The principal left the school the following year and moved to a high school outside the community. The SECME program at School A subsequently struggled with participation in all District sponsored events.

The SECME program at the school-site was coordinated by an African-American male and implemented only with the gifted students in his classroom. With an after-school membership of only 30 students, this translated to less than two percent (2%) of the student population. In the 2004-2005 school year of this research study, an additional precollege engineering program developed by a state university in collaboration with the District SECME program, was offered to the school. This program involved pairing a mathematics and science teacher, several engineering modules developed by the university, participation in SECME Saturday activities and a two-week summer engineering camp. There were ten mathematics and engineering modules presented to students in small classroom-type instruction held on a partnering community college campus. Teachers were provided professional development on the modules and by mathematics faculty from the partnering local community college. All participating teachers received a stipend for the Saturday instruction and professional development.

Students reacted positively in the anticipation that the program was inclusive of all students. The comment was that the students belonged to this secondary program and not SECME because "SECME is only for gifted students." The students seemed to clearly voice a discrepancy between how opportunities were made available to all students through this SECME program extension and how students were traditionally recruited for the program at the school previously. Clearly, the students were not associating the enhanced SECME program with what had been in existence at their school for several years.

5.2.2 Case study school B

The Administrative Leader was data-driven. She wanted to know the statistical outcomes of programs and how they impacted her students' achievement in order for it to be presented to parents. She was very supportive of SECME activities at her school.

Table 5.5 Interview responses from School B SECME student club participants

	Participating in SECME makes me feel	"How can we get more students to join SECME?"	"What do you like best about SECME?"
African American Male	"Smarter"	"Make it sound fun"	"Building – bottle rockets, airplanes" "Drawing"
Hispanic Male	"Smart in engineering and feel like I'm in school, but its fun" "" Like an engineer	"Keep it fun for them to stay"	"Building, coming up with ideas"

She opened her building on Saturday and during the summer for the students to participate in SECME activities. The coordinator recruited students primarily from her gifted classes. There was parental involvement. She was successful in recruiting the Parent Teacher Student Association (PTSA) president whose children were a part of the program. This provided financial support to the program at the school. On a visit to one of the after-school SECME club meeting, the male students were separated from the participants and were asked several questions in a group interview. The questions and responses from the middle school male students are listed in Table 5.5

As indicated in Table 5.5, the first question: *How does participating in SECME make you feel*? yielded responses that were similar to those given by the students at the Saturday engineering design seminars. Because all student responses collected at the Saturday seminars indicated the student's affiliated school, the researcher could identify that the responses given at the seminars were from students from schools other than School B.

5.2.3 Case study school C

The Administrative Leader was in a unique position in that her school had a designated magnet program for the Arts. Therefore, students were recruited to attend the school through a highly selective application process. She was extremely supportive of her staff and SECME. For several years, the school implemented a school-wide SECME program, and Saturday Science Olympiad. The event took place before the District SECME Olympiad in an effort to encourage as many students to participate in the program. The winners of the events submit their projects at the District competition. The coordinator left suddenly to pursue a career outside education within the same city, and a new teacher took his place. The new coordinator sought assistance from the District and continued the implementation of the annual school-wide competition. At the end of the school year, this SECME Coordinator had also left the school and the program.

In 2004-05 of this study, a white male teacher new to the SECME program attended a district sponsored workshop and indicated that many of the non-magnet, local community students found difficulty behaving and performing to the expectations of the school and needed an “alternative education” school to meet their needs. He continued to say that this behavior was usually identified during the first semester of school. Upon completion of the SECME workshop, which emphasized equity and appreciating student diversity, the teacher indicated that he learned a lot and found the program beneficial. Further study and follow-up is needed to see if other staff members shared his original perceptions, and if his perceptions had truly been altered after more involvement in the SECME program.

Even with this self-expressed perception adjustment, the researcher observed a lack of African American student participation at School C’s annual school-wide SECME competition. Of significant note, the school’s population was only 10 percent Black (M-DCPS, 2005) in a community that was 25 percent Black. When asked about the lack of participation, the Administrative Leader noted that there used to be more participation from minority students in the neighboring community, especially the females. She also indicated that it would be addressed in the next school year. Unfortunately, the administrative leader was promoted, and also left the school. The constant change of program leadership, however, was not evident in the school’s participation in district SECME program offerings. The school also continued to implement their school-wide implementation of the program and. school-site Olympiad. During the course of this research, School C had the most parent participation at Saturday design seminars. However, the presence of African American students from School C at these events was still non-existent.

5.3 SECME Coordinator/Teacher Program Comments

The researcher developed the *2004-2005 SECME School Survey for Teachers which* was completed by 13 SECME School coordinators and 2 SECME teacher team members at the Annual Awards Breakfast Banquet. Their students had participated in the Olympiad competition a couple of months prior to the banquet. The ethnic and gender breakdown of the teachers follow in Table 5.6.

Table 5.6 Ethnicity and gender of SECME middle school teachers attending annual breakfast awards banquet:

Ethnicity and Gender	Number of Participants
Hispanic female	10
African American female	1
Unknown female	3
White male	1

The teachers indicated that the estimated amount of time that they as SECME Coordinators spent with students after-school ranged from 20 – 130 hours.

Lack of support was a common concern expressed by the coordinators. Often, managing the program alone at a school-site took its toll on teachers. Although the program design called for a team of teachers working together at a site, there were no mandatory funds provided by the District office. School sites would only be able to provide a financial stipend of $500 to one faculty member, if any. Even without financial incentive, teachers still seemed to participate in the program and sought alternative methods of program delivery such as implementing SECME during the school day as an elective course.

Coordinators, additionally, expressed frustration with the design of the competitions events and having to carry out the program on their own. When the competition handbook was provided, one coordinator voiced concern through an email that stated,

> Are you ever going to consider having events not happen concurrently? It really does not help the kids work as a Club (group). It makes me designate them to a particular area. Other schools have all science students join SECME. Then they can generate their "best" students (i.e. Bridge, Mousetrap Car, etcetera.) I am considering not doing SECME anymore because it pretty much is didfficult [difficult] when you do not have teachers that can help out. Other schools have all kids join SECME. I don't think this is fair. I would like to chat with you…Can we coordinate a ate [date] and time to talk? (March 22, 2004, 12:22 p.m.)

Competition has the reputation of bringing out the best and the worst in some participants.

5.3.1 Professional development

Professional development of teachers is at the core of the SECME model, both nationally and in the school district involved in this study. The goal of the national SECME organization is to motivate and inspire teachers to increase the participation of underrepresented students in STEM careers by entering and completing postsecondary studies in these fields. Teacher engagement of students in more hands-on, real-world activities is a challenge in science classrooms. An impediment to engage students in these types of activities is the teacher's lack of knowledge on how to implement these strategies. Therefore, teachers need to be empowered with strategies and support through continued professional development to carry-out these activities. The SECME program attempts to meet this challenge by providing the teachers with the necessary tools and strategies.

5.3.2 National SECME Summer Institute

An African American male teacher was overcome with excitement upon his return from the 10-day national summer institute. He indicated that he was ready to leave teaching when he was given the opportunity to attend the institute. He was grateful that he had the opportunity to meet "Black professionals in person – engineers, doctors." He expressed that it was the first time that he had met such accomplished people in person. This was just one sentiment of frustration with teaching expressed that may be representative of other African American classroom teachers in the school district involved in this research on whom a 10-day SECME institute may have the same revitalizing effect.

5.3.3 District sponsored mini-conference

As a scaled-down version of the national summer institute, the school district implemented a district sponsored two-day SECME mini-conference that was held at a local college/university partner campus. At this event, teachers participated in many of the activities that prepared students for STEM competition. The day would open with a general session where participants from elementary through senior high schools met together. In 2005, there were 106 teacher participants, of which 34 represented middle schools.

Some new participants to the SECME program indicated that they were sent to the workshop by administrator recommendation or invitation. Overall teacher reflections on the SECME workshop sessions follow: “Informative”; “Enables networking”; “It is a great program that allows the student to explore different solutions for problems it gives them self esteem to believe that they can go out and be successful in the world”; “This is lifelong skill” and “It is a wonderful, highly motivating program”, “Outstanding! and “Fab-U!”.

5.3.4 Saturday engineering design seminars

Middle School SECME teachers participating in Saturday Engineering Design Seminars responded to questionnaires about the effects of SECME seminars on responses, this researcher grouped them into two categories: 1) Resource and content empowerment to better facilitate students in their classrooms and 2) Enthusiasm.

Table 5.7 Some middle school teacher responses to the researcher generated question “How do seminars like these affect teachers?”

	Resource and content empowerment to better facilitate students in their classrooms	Enthusiasm
–veteran SECME Coordinator (3 years or more)	“Assist students with concepts & practical experience.” *(5 years)* “Assist with concepts and practical experience” *(5 years)* “We learn too.” *(3 years)* “A better understanding of projects” *(7 years)*	“energizes and generates enthusiasm” *(3 years)* “more eager to show students how to do activities” *(3 years)*
new SECME Coordinator (2 years and less)	“help to instruct students” “provides networking & resources” “Same [as students] they learn and get experience” “prepare teachers to better equipt [equip] students in the field of math/science” “Seminars like these give teachers a better enlightenment on how to build the mousetrap car” “Better preparation”	
new SECME Teacher	“It increases my ability to help my students gain a better understanding in math” “The [They] broaden our knowledge “They clarify concepts & is a great curricular activity to implement at school.” “I am becoming more comfortable with building bridges”	

All comments were not as positive as those expressed in Table 5.7, where teachers made clear connections to the mathematics and science concepts and their connections to the projects being designed and built for competition. A sixth grade SECME middle school teacher at the Mousetrap Car Seminar (0.5 years with SECME) indicated the following responses:

> Question: How do seminars like these affect teachers?
> Response: "I needed more how to create a working mousetrap car help, less fundamental physics for beginning middle school students."
> Question: How do seminars like these affect students?
> Response; "This was too high level for my middle school students."

Through Saturday Engineering Design Seminars, the SECME program seemed to build teaching capacity by providing 1) subject-area content knowledge, 2) a forum for teachers to network and share ideas and resources, and 3) a renewal of enthusiasm for their career. A new SECME teacher also indicated that it helped to get students involved in math and science.

5.4 SECME Student Program Comments Related to this Study's Research Questions

RQ 3: What are students' attitudes towards mathematics and science following their experiences in a precollege engineering program?

Student Reflections at Saturday Engineering Design Seminars

SECME students often self-select to be a part of the program at their schools. An interest in participating in extracurricular mathematics and science activities could be an indicator that they are already interested in science and mathematics course content. The students participated in the program at their respective school-sites, some of whom made the additional effort to attend Saturday events such as the Saturday Engineering Design Seminar.

At these seminars, all participating students were surveyed and the responses were separated for the purposes of this research. The students responded to questions pertaining to student achievement in mathematics and science with respect to gender and ethnicity. Some of the questions and responses of the participating middle grade male follows in tables 5.8 – 5.10. The researcher asked to respond to the statements:

Do you like science? SECME makes me feel: and *Participating in a seminar like this makes me feel:*

Table 5.8 Some middle school male student responses to the question: Do you like science?

Ethnicity	Response		
	Yes	No	Unsure
Black	1	0	0
Hispanic	9	0	1
White	0	0	0
Total	10	0	1

The data in Tables 5.9 and 5.10 were retrieved from the electronic responses to the attitude survey that was accessed by the SECME schools. The responses suggest that the SECME program students, regardless of gender or ethnicity, feel good about themselves. The females are more articulate in their responses and also seem to make the connection between SECME and their science and mathematics studies. Additionally, there appears to be a disproportionate number of African American and White student respondents - an indication of their low representation. In Tables 5.9 and 5.10, five out of 36 respondents (14%) were African American compared to the district percentage of 29% (Miami-Dade County Public Schools, 2005) and two out of 36 (0.06 percent) were White, again compared to the district percentage of 9% (Miami-Dade County Public Schools, 2005). Also, this was not an accurate reflection of the district SECME program profile as indicated in Chapter 3, where the percentage of students in the middle grades SECME program district-wide in 2003 - 2004 school year were 25% African American and 10% White. In the 2004 – 2005 school year, the ethnic distribution was 25% African American and 25% White.

Table 5.9 Written responses by middle school female SECME students to the statement: SECME makes me feel…

Ethnicity	Female responses
African American	Glad because it expresses scientific abilities for kids
	SECME makes me feel like im part of the world. it makes me feel like a scientist even though i dont want to be one when i grow up. i feel on top of the world and smart. i like SECME very much cause it feels like i have invented something new and important
	Doing the Experiments like the bottle rocket experiment
Hispanic	confident in science studies and education
	Glad, because [because] us kids need education in science even if we hate i [it] we need it. it is also fun so it is a great idea to have SECME.
	like a good person with a lot of manners in the table and i feel like a model and sometimes i feel like a genious [genius] and a braniack.....I LUV STUDYING!!!!!! ITS MY PASSION......
	SECME makes me feel reative [creative] because you need to use your creativity to enter SECME.
	good because it teach thet [that] science is fun
	SECME is all right it challenges kids to do interesting projects what i like about secme [SECME] is that i learn new things and do alot of interesting projects.
	What i like best is that we do fun projects when we do SECME. able to discover new things to learn from and enjoy the time that i spened [spend] on it!
	proud of myself of doing an egg drop container
	confident in science studies and education
	Secme [SECME] makes me feel responsible about my work.
	Secme [SECME] makes me feel very smart, very original and great about myself. It makes me feel original,smart, and great about myself because in order to reach my goals I ust [must] know math and science and that is what secme [SECME] has taught me and will keep on teaching chi [children]
	The different science experiments discover new things.
	I like best is that it makes me get intrested [interested] in scince [science] and math and is a fun way to learn about new things.
	it makes me prantice [practice] my science skills, and it makes me review math and it makes me feel more secure in science and math
	Secme [SECME] makes me feel very important and smart due to the fact that i want to be a lawyer and the more science you know the better you are at your careers
White	Happy

Table 5.10 Written responses by middle school male SECME students to the statement: SECME makes me feel…

Ethnicity	Male responses
African American	like a real mechanic working on things
	Smarter
Hispanic	GOOD
	the mousetrap car and the bridges are intresting [interesting] because i like arcitecture [architecture] things not science thinks [things] as much
	Its fun i hpe [hope] i can do it again.
	proud of myself
	It lets me think of thinks that are out of the box or different or exciting.
	Intelligent , it makes me feel as though I am capable of accomplishing what I used to believe impossible. For instance, I would have never thought myself ca[able [capable] of building a wooden bridge that actually supported weight. Overall, it makes believe that I [can]
	Smart because i can succed [succeed] in all of there [their] taks. [tasks] I fell able to acomplish [accomplish] all chalenges [challenges] that come my way. In fact i recetly [recently] made a bridge for secme.[SECME] And i'll tell you that was not easy but i over came the obsticel. [obstacle]
	Smart
	like imagining I'm an overachevere [overachiever] and I can see myself success in life
	involved 'it fun.'
	Good because im [I'm] learning something new.
	Good because I have learn [learned] about the importance of building stuff.
	Confident in my-self
Other: Multicultural	The best thng [thing] I like from SECME is the competitions, there [they're] so fun.
White	good to be in Secme

The researcher also compiled sample responses from one of the Saturday Engineering Design Seminars. Since female students had previously indicated the connection between SECME and mathematics and science, the male student responses were isolated to determine if the males also made academic connections with the program. The seminar format tried to maintain a maximum of 45-minute discussion and interactive presentation of mathematics and science concepts through demonstrations and PowerPoint slides with minimal text and graphics/pictures. Immediately after the formal presentation, students built their mousetrap cars in groups of two- to three-member teams. These teams sometimes included parents and teachers working and learning with students.

Student responses to the statement, *Participating in a seminar like this makes me feel:* are captured in Table 5.11 which represents some of the comments presented by male student participants at the SECME Saturday Bridge Engineering Design Seminar. The seminar was presented at a local university's College of Engineering campus by graduate and undergraduate students from several engineering societies who were in various stages of completing their studies. The seminar started at nine o'clock in the morning, and many students arrived as early as eight o'clock. The workshop ended by noon and students had engaged in a presentation on the historical perspective of engineering and bridge construction, along with time spent interpreting the international bridge competition rules that would be used as one of the SECME Olympiad events. The participants spent time sketching trusses on grid paper and practiced cutting basswood sticks and formulating a rough, initial construction, using fast-drying wood glue. Of the 22 surveys returned by the middle school male participants, 8/22 (36 percent) rated the seminar as "outstanding" and 13/22 (59 percent) gave a rating of "good" and only one student (0.05 percent) indicated a rating of fair. These sampled male students also made career connections with the program seminar and classroom connections with the concepts discussed. Table 5.10, for the most part, portrayed SECME students as liking science. The most noted impact of the seminars on male students were the hands-on opportunities.

> "It was good. It was a little boring in the beginning, when they talked." - Eighth grade Hispanic American male's response about participating in the SECME mousetrap car seminar.

Table 5.11 Written responses by middle school male SECME students to the statement: Participating in a seminar like this makes me feel:

Ethnicity	Male responses
African American	Great
	Good
	Smarter
Asian	Makes me feel more educated and gets me going
	A little more interested in building.
	Real interesting in science and mathematics.
	Good
Hispanic	It makes me feel more confident to study architecture.
	Very educated
	It makes me feel prepair [prepared]
	Informed on the engineering carears [careers]
	It makes me feel good to know that there are a lot of people who help you along the way.
	Smart
	Like I'm in school just not with the same teachers.
	Like I am in school, exept [except] I'm having fun
	Smart in engineering and feel like I'm in school, but it's fun.
	Like an engineer
	It makes me feel like there is a good challenge ahead of you.
	An engineer
White	Very educated
	Great. This was much funnier and less confusing than the Mousetrap Seminar.

5.4.1 Field experiences at engineering sites

Groups of 20 students and their SECME teacher met engineers and observed them in action at their worksites. Two such sites are described below along with student commentaries and reactions following the visit.

Engineering Site A was a hurricane engineering and testing company. The students listened to a lecture on the operational aspect of the facility and then participated in demonstrations on materials and their ability to withstand hurricane conditions.

> Hispanic American Male student, grade 8, whose career goal was law/music: The student indicated that the tour held his interest, the tension test that pulled an object apart until it broke, making a loud sound, was the most interesting aspect of the tour. The least being the measurement session. He indicated that he would not pursue a career in that field "because un (I'm) not interested." However, he would recommend the field trip to other middle school students "because it is very interesting."

A second student's commentary indicated a similar interest in the tour's demonstration component.

> Hispanic-American male student, grade 8, whose career goal was computer programmer indicated that the tour held his interest and found the most interesting part when the "2x4 hit the glass." He did not have an interest in a career in that field "because I've already chosen a career." He too would recommend the field trip to another middle school student "because trip is very interestion (interesting)." All male students attending the tour that day indicated that the breaking of the glass was the most interesting part of the trip.

Engineering Site B was a college of engineering campus visit. Each year, in February, intentionally coinciding with National Engineering Week, the institution hosted a day of engineering tours and challenges for students from elementary, middle and senior high schools. Schools were invited to attend and the district SECME office provided substitute coverage for the teacher, along with transportation and the hosting university provided lunch.

> Thank you for all your help and funding our trip. Last year they [the students] had a great time learning about the campus and the wide variety of courses…I can't wait to see what student competitions they have created for us (participating middle school SECME teacher comment).

In later years, as a result of moratoriums instituted by the school board that indicated that teachers could not be pulled from the classroom from January – March, transportation was still funded by the district office, but not substitute coverage for the participating teacher's classroom. This moratorium was in place to assist student preparation for high stakes testing. This directive implied that correlations were not evident between achievements on these high stake tests and real-world experiences gained through the exposure to higher education activities, and/or student and teacher motivation to apply science concepts learned in the classroom to engineering projects.

5.5 Summary

The qualitative data attempted to respond to several of the research questions. With respect to Research Question 1, the intent of the SECME program, SECME students and parents indicated that the program influenced educational choices and encouraged an interest in mathematics and science that was not there previously. When opportunities to participate in Saturday engineering activities were provided, the majority of students participated willingly. However, the Hispanic American males were more apt to attend the programs even if transportation became an issue. The Hispanic American SECME students seemed to have greater resources available to attend engineering activities across the District, whereas, the African American males more frequently only attended events held in proximity to their home or if the program provided transportation.

In terms of Research Question 2 and the implementation of the program, one of the common concerns voiced by SECME coordinators was the inability to garner support from other teachers at the school-site. District support seemed to play an integral support system for the program since it coordinated the Saturday Engineering Design Seminars for student, teachers, and parents along with teacher professional development, and engineering site visits and role models. The district followed the national SECME model to provide an alliance of industry and university/college partnerships to support teacher preparation and motivation to increase the successful participation of underrepresented students in science, technology, engineering and mathematics (STEM) postsecondary education and eventually STEM-focused careers.

Schools that implemented the SECME program school-wide, seemed to secure the most parental support at Saturday Engineering Design Seminars as was evident with School C from the case study. These parents, however, may be active in their children’s school activities, regardless, because of the specialized magnet program environment at that particular school. These parents and students are typically more driven than the average. Because a triangulation methodology was used in the study, there was evidence that the program provided access and opportunity to students, teachers and parents in the STEM areas, however, a more concerted effort needs to be made to get more African American student participation at the District sponsored events for exposure to postsecondary education campuses and role models presenting at the seminars, such as practicing engineers and/or engineering students.

With respect to Research Question 6, there were comments by African American males indicating that students performed better in mathematics because they were in programs that have that focus. This supports the vital role that precollege programs like SECME plays. Although the program was inclusive and available to all students in the school system, the population of this school district was unique in that the majority was a minority group. The demographics of the SECME program in 2004 – 2005 were: 26% African American, 56% Hispanic American, 13% White which, for the most part, mirrored the demographics of the school district.

In response to Research question 7 and the students, parents, teachers' and researcher's perceptions of minority achievement, the data revealed that there seemed to be some contradictions between the perceptions towards achievement and action to encourage minority achievement among all groups. Even though students participated in mathematics and science activities through SECME and felt as though they were excelling, there were still perception slanted towards the majority being better equipped genetically to excel. African-American parents were not participating in the precollege program activities hosted by the District. Additionally, teachers indicated that the program encouraged minorities, yet there were schools that did not have minority students participating in their school-site SECME program. The researcher also indicated that certain minority groups seemed to have been addressed sufficiently and there should be greater emphasis placed on one minority group.

CHAPTER 6

CONCLUSIONS, IMPLICATIONS, LIMITATIONS AND RECOMMENDATIONS

6.0 Overview

With the increasing demand for science, technology, engineering and mathematics (STEM) literate citizens that will meet the workforce demands of the 21st century, there seems to be a logical penchant for educational systems to embrace programs that provide students with exposure and opportunities in these areas. Students need the foundational skills in mathematics and science that interconnect to develop sound engineering skills. Research has indicated that access and exposure are vital for minority students to pursue careers such as those in the STEM fields. There are four sections in this chapter. Section 6.1 discusses the responses to the research questions. Section 6.2 describes the significance and implications of this research. Section 6.3 presents the limitations of this study, and Section 6.4 provides recommendations for further research.

6.1 Conclusions - Responses to the Research Questions

6.1.1 Intention of SECME program (Research Question 1)

After school programs offer the ideal environment to keep minority students from engaging in behaviors that are detrimental to their physical and developmental well-being. The intention of the SECME program is to provide support to teachers and motivation for minority students. SECME, formerly the Southeastern Consortium for Minorities in Engineering, was intended to provide an alliance of industry and university/college support for teacher preparation and motivation to increase the successful participation of underrepresented students in science, technology, engineering, and mathematics (STEM) postsecondary education and eventually STEM-focused careers. This program could be an integral component for realising the nation's goal of closing the achievement gap and providing exposure to STEM for the subgroup that will soon be the majority in the United States. This national program model was implemented in the school district involved in this study.

6.1.2 Implementation of the SECME program (Research Question 2)

SECME was implemented in the school district involved in this research through a Central or District office that provided a series of STEM workshops for students, parents, and teachers, all focused on the culminating STEM competition event, the SECME Olympiad. The program, however, did not sufficiently attract African American students to the Saturday Engineering Design Seminars. Therefore, this group of students engaged in a limited number of District-sponsored events that provided exposure to postsecondary education campuses and role models, such as practicing engineers and/or engineering students. The program did, however, successfully leverage support from industry and university partners and provided engineering site visits to minority students, affording the African American students with this critical STEM career contact during the school-day.

6.1.3 What were the reliabilities of the modified scales of the Test of Science Related Attitudes (TOSRA) and the Test of Mathematics Related Attitudes (TOMRA)? (Research Question 3)

The reliabilities for the modified TOSRA instrument were established by the Cronbach's alpha coefficient. The internal consistency of the 8-item scale on the Enjoyment of Science Lessons and the 7-items scale on the Interest in Science scales were 0.89 and 0.84, respectively, for the pretest and 0.89 and 0.84 for the posttest. This indicated a high consistency in responses on the pre and posttests. Similar consistencies were found in the 8-item scale for the modified TOMRA with respect to Enjoyment of Mathematics Lessons, which revealed a 0.92 and 0.91 for the pretest and posttest, respectively. The Attitude to Mathematics Inquiry and the Adoption of Scientific Attitudes was much lower with alpha coefficients of 0.58 and 0.52 for the pretest, respectively and 0.57 and 0.58 on the posttest.

6.1.4 What were the changes in SECME and non-SECME students' achievement in science and attitudes towards science following their experiences in a precollege engineering program (Research Question 4)

After participating in the SECME program, the data revealed that there was no statistically significant difference for both the SECME and the non-SECME students with respect to the changes in achievement in science and their attitudes towards science. There were, however, statistically significant differences between White and American – African American and between Others and African American students on the TOSRA scales for non-SECME students. With respect to the Science SSS scale scores, there were statistically significant differences between 1) students of other ethnicities and African Americans, and 2) Hispanic Americans and African Americans; in both instances, these differences were not in favour of African American students.

Implications of these findings could suggest encouraging data for narrowing the gap for minority student achievement and attitudes in science because regardless of ethnicity, there was no difference in attitude or science achievement among students in SECME. However, it should also be noted that SECME students mostly self-select participation in this program which incorporates the application of science concepts through projects.

6.1.5 What were the changes in SECME and non-SECME students' achievement in mathematics and attitudes towards mathematics following their experiences in a precollege engineering program? (Research Question 5)

There were no statistically significant differences in *achievement in mathematics and attitudes towards mathematics* following the SECME program between SECME and non-SECME students.

The lack of significant differences in attitudinal changes among SECME students could be attributed to the SECME students self-selecting to be involved in the program. This self-selection would indicate an interest in mathematics and/or science prior to entering the program. This was further attested to by student comments such as, SECME makes me feel: "No different than I was before."

6.1.6 Relationship between attitudes towards science/mathematics and academic achievement following their experiences in a pre-college engineering program (Research Question 6).

There were no statistically significant relationships between students' scores on the three attitude scales and their achievement on any of the four cognitive measures. Of particular note, however, is that the students in this study, on average, outperformed the state and district averages on the Mathematics and Science SSS.

6.1.7 Students' parents', teachers' and researches' reflections on minorities' achievement in science and mathematics (Research Question 7).

Student reflections

The qualitative data suggested that the SECME program appears to make students, regardless of gender or ethnicity, feel good about themselves. The females were more articulate in their responses and also seemed to make the connection between SECME and their science and mathematics studies. Similarly for male students attending the SECME program seminars, connections were made to careers and classroom mathematics and science concepts. As shown in Table 5.10, for the most part, the data portrayed SECME students as liking science.

Parent reflections

Parent reflections at the Saturday Engineering Design Seminars indicated that the program allowed for increased curiosity and enhanced learning opportunities for their children. Although many parents attending the seminars did not indicate gender or ethnic biases with regard to performance in mathematics and science, there were some parents who believed that males performed better in mathematics. There was a notable absence of African American parents at the SECME Saturday events.

Teacher reflections

Through the SECME program, teachers were provided with resources and support to implement the SECME program with their students. Additionally, the teachers increased their content knowledge and felt empowered to better assist their students. Teachers did, however, express the need for additional school-site support from their peers to implement the program through the intended team model. There were indications by SECME teachers and coordinators as to the program's ability to encourage minority students to pursue science, technology, engineering, and mathematics (STEM) careers and provide them with the necessary content. However, an interesting comment was made by one of the teachers with respect to the program encouraging "anyone who shows interest." This comment implies that all SECME schools are not demonstrating active recruitment efforts to target students who would typically not show interest, the historically underrepresented and underserved populations.

Researcher reflections

This researcher admittedly needs to also become more proactive in ensuring that the schools participating in SECME target the African American male and female students for the program. Additionally, any minority student that does not show an interest but needs the exposure and encouragement should also be identified and included in STEM activities. Additionally, working more closely with minority science, mathematics, and engineering organizations to solicit role models for students would allow them to see the possibilities beyond athletics and realize that all students can achieve and be successful at anything, especially STEM. Exposure and encouragement are the key influences.

6.2 Significance and Implications

This large urban school district demonstrated the national trend of increased minority populations. This was evident in the increase in grade-8 ethnic sub-populations, Black non-Hispanic, Hispanic and other. The only subgroup in grade-8 showing a decrease was the White non-Hispanic. The presence and persistence of minorities in science and mathematics, the influences that affect minority achievement, and a gender comparison as it relates to academic achievement are factors that contribute to the achievement gap. Unless all students, especially minority students, are encouraged to stay in school and are provided with the resources to pursue advanced mathematics and science courses, the United States will be without the local talent to meet the needs of its science, technology, engineering, and mathematics workforce, not to mention, maintain its competitive edge globally. Special attention needs to be focused on minority education that eradicates the achievement gap, as the minority will eventually become the majority. The United States census predicts that minorities will represent 50 percent of the population by 2050.

Institutionalization of the SECME program seemed to be important for stability of the program at schools, as was evident with case study School C. When SECME became a part of the school program, even when there was a change in SECME school-site leadership, the program continued. The only negative aspect was the implementation emphasis, more so, on the advanced students, as opposed to the entire student population. The district office could make a stronger emphasis to include the SECME model in the middle school curriculum to ensure that all schools implement the engaging aspects of the program, such as the hands-on engineering competitions, thus ensuring equity in reaching all student groups in the county.

Walberg's theoretical framework categorised by student aptitude, instruction, and psychological environment examined specific factors associated with achievement and learning outcomes. The nine educational productivity factors that influence each other and subsequently student learning encompassed Ability/prior achievement, motivation and attitude, quantity of instruction, quality of instruction, home environment, classroom environment, peers, and use of out-of-school time (Thomas, 2000). Specialised pre-college programs such as SECME have been developed to help close the achievement gap and encourage students to participate in and successfully complete postsecondary instruction in STEM. The program seems to address many of these aforementioned educational productivity factors. Further analysis, through a curriculum framework, would reveal the intent, implementation and realised outcomes of the precollege program. The framework revealed that the implementation of the program is attempting to meet the intent; however, further emphasis needs to be placed on exposing African American student to the Saturday Engineering Design Seminars.

The implication from the data that, regardless of ethnicity, the SECME students showed no statistically significant differences in the Science Sunshine State Standards (SSS) scale score demonstrates the effectiveness of the program in reducing the minority achievement gap. Even though there was a statistically significant difference in Mathematics SSS and Science SSS between SECME students and non-SECME students involved in the study, it must be noted that both groups of students outperformed the district average scores.

A possibility as to why there was not much difference between the attitudes towards science and mathematics in the pre and posttests could have been attributed to students in the program elected to be in the program because they were interested in science and/or mathematics. As shown in tables 4.5 and 4.6, all pretest scores on the TOMRA scales were above 3.0, the central point, and in some cases such as Enjoyment of Science Lessons, at 3.72 very high. Additionally, the students' attitudes towards enjoyment of the subjects did not change

As determined by the analysis of attitudinal and achievement data, Adoption of Scientific Attitudes is a significant, independent predictor of FCAT Mathematics Achievement Level. Therefore, increasing student scientific attitudes would seem to be beneficial in raising achievement levels in mathematics.

6.3 Limitations

The limitations experienced during this research were multi-faceted. There was no single, prescribed method of implementing the SECME program at each school-site. The intent of the program was to provide access and opportunity to minority students through a pre-college program. Provided that schools met the intent of SECME, their implementation methodologies were not dictated. This proved to be difficult if trying to conduct research that has a quasi-experimental design. Some schools across the district implemented the program during school hours, integrated in the curriculum, while others maintained after-school clubs.

Furthermore, although the school district involved in the research was populated by minorities, there still existed racial isolation across the schools. There were extensive efforts to create racially diverse student populations, but the reality was that there were many neighbourhoods that remained predominately Hispanic or African American. To increasingly compound the limitations of the study, racial self-identification by students was not always as expected. When students were asked to indicate whether they were African American or Hispanic, there were many participating students who often identified themselves as Haitian American instead of African American (AA) and Cuban American instead of Hispanic (H). The decision would be made to disregard culture, for this study, and maintain the three ethnic categories of African American, Hispanic and White.

The most critical limitation was the restrictions imposed by the District for the collection and dissemination of surveys that, therefore, necessitated multiple attempts to retrieve data from the teachers in various formats. The more than seven months time-frame between pretest and posttest of students, also hindered the collection of data; especially at the end of the school year when the teachers and the researcher were overwhelmed with responsibilities to close-out the school year. Additionally, a larger number of respondents for the collection of quantitative data were reduced by the fact that the Florida Comprehensive Assessment Test Sunshine State Standards and the Norm Referenced Tests for science are only administered in the middle grades at the grade eight level. This reduced the population of middle school students that were reported in the data as participating in the SECME program.

6.4 Recommendations for Further Research

Improving the attitudes of minority students towards science in the middle school years is critical to encourage the at-risk populations to enjoy mathematics and science, especially minority males who tend to be overrepresented in the judicial system. After-school and enrichment programs that provide students with safe, academically rich learning environments have provided resources and positive academic reinforcement. If Federal and State funding is to continue increasing for after-school programs, then longitudinal data and studies on their effectiveness will be essential for documenting successful minority-targeted programs to secure financial support.

A longitudinal study is necessary to further analyse the full impact of precollege engineering programs on student attitude and achievement in mathematics and science, and their pursuit and persistence in postsecondary science, technology, engineering, and mathematics (STEM) studies and careers. This study looked at the current state of the SECME program in a large urban school district over a two-year period. In order to conduct a thorough analysis of the intent of the program, to increase the presence and participation of underserved, underrepresented populations in postsecondary studies in STEM, with the ultimate goal of successful completion and entry into these careers, it would take many years to track the students from middle school years through career. However, a study of this magnitude would prove beneficial, especially considering the current trend of minority growth in the United States and the nation’s precarious standing as global leaders in STEM.

This study aimed at analysing the intent of a precollege engineering program, specifically SECME, with respect to motivating students through STEM activities, and the interactions that involved students, parents, teachers, and community partners working together.

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NOTES

Figure 2.1
Excerpt from Table 7: Average FCAT SS S Mathematics Scale Scores: District and SECME Students, by Curriculum Group, 2004 and 2005

		DISTRICT/SECME								STATE	
		Standard Curr		ESE		LEP Two Years/Less		All Students		All Students	
		2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Grade 8	District	310	312	226	238	263	258	298	301	311	313
	SECME	362 (197)	340 (236)	310 (5)	253 (20)	*	*	360 (202)	333 (259)		
	Diff	+52	+28	+84	+15	**	**	+62	+32		

*No scores displayed because there were less than 5 students in group.
**Difference not computed because there were less than 5 SECME students in group.

Figure 2.1 indicates a breakdown of the average Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards Mathematics Scale Scores for students across the school district by curriculum group for District and SECME students in grade 8 for the 2004 and 2005 school years. For the curriculum groups, standard curriculum and Exceptional Student Education (ESE), SECME students, on average, outperformed the District averages. There were fewer than five Limited English Proficient (LEP) students in the SECME program for the years analysed. Standard curriculum SECME students, on average, outperformed the State average scale scores. The values in parentheses indicate the number of SECME students tested. Of note, District scale score averages were below State averages.

Figure 2.2
Table 9: Average FCAT SSS Mathematics Scale Scores by Ethnicity: District and SECME Students, Grades 6-8, for Standard Curriculum Students and All Students Tested, 2004 and 2005

	Grade 8					
	District		SECME		Diff	
	04	05	04	05	04	05
Standard Curriculum						
Black	288	290	339 (27)	302 (71)	+51	+12
Hisp	314	317	361 (135)	351 (122)	+47	+34
White	336	339	381 (21)	370 (29)	+45	+31
All Students						
Black	275	278	339 (27)	292 (82)	+64	+14
Hisp	302	305	359 (139)	347 (131)	+57	+42
White	328	331	380 (22)	361 (30)	+52	+30

Figure 2.2 reflects a breakdown of the average Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards Mathematics Scale Scores for students across the school district by ethnicity for standard curriculum and all students in the district tested in grade 8 for the 2004 and 2005 school years. For all ethnicities, SECME students, on average, outperformed the District averages. Additionally, in 2004, Black SECME students, on average, outperformed all other ethnicities in the District. The values in parentheses indicate the number of SECME students tested.

Figure 2.3
Excerpt from Table 11: Average FCAT SSS Science Scale Scores and Number Tested: District and SECME Students, Grades 5, 8, and 11, 2004 and 2005

		DISTRICT/SECME								STATE	
		Standard Curr		ESE		LEP Two Years/Less		All Students		All Students	
		2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Grade 8	District	281	283	207	213	215	217	269	272	286	291
	SECME	335 (194)	320 (231)	312 (5)	244 (19)	*	*	335 (199)	323 (253)		
	Diff	+54	+37	+105	+31	**	**	+66	+51		

*No scores displayed because there were less than 5 students in group.
**Difference not computed because there were less than 5 SECME students in group.

Figure 2.3 indicates a breakdown of the average Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards Science Scale Scores for students across the school district by curriculum group for District and SECME students in grade 8 for the 2004 and 2005 school years. For the curriculum groups, standard curriculum and Exceptional Student Education (ESE), SECME students, on average, outperformed the District averages. There were fewer than five Limited English Proficient (LEP) students in the SECME program for the years analysed. Standard curriculum SECME students, on average, outperformed the State average scale scores. The values in parentheses indicate the number of SECME students tested. Of note, District scale score averages were below State averages.

Figure 2.4
Excerpt from Table 12: Average FCAT SSS Science Scale Scores by Ethnicity, District and SECME Students, Standard Curriculum Students and All Students Tested, Grades 5, 8, and 11, 2004 and 2005

	Grade 8					
	District		SECME		Diff	
	04	05	04	05	04	05
Standard Curriculum						
Black	258	257	308 (26)	280 (67)	+50	+23
Hisp	285	287	333 (134)	342 (122)	+48	+55
White	315	323	367 (20)	369 (28)	+52	+46
All Students						
Black	246	247	308 (26)	270 (78)	+62	+23
Hisp	272	275	332 (138)	338 (130)	+60	+63
White	306	315	367 (21)	362 (29)	+61	+47

Figure 2.4 reflects a breakdown of the average Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards Science Scale Scores for students across the school district by ethnicity for standard curriculum and all students in the district tested in grade 8 for the 2004 and 2005 school years. For all ethnicities, SECME students, on average, outperformed the District averages. Additionally, in 2004 and 2005, Hispanic and White SECME students, on average, outperform all other ethnicities in the District. The values in parentheses indicate the number of SECME students tested.

Figure: 2.5
Excerpt from Table 17: FCAT NRT Mathematics Median Percentile Scores: District and SECME Students, 2004 and 2005

		DISTRICT/SECME								STATE	
		Standard Curr		ESE		LEP Two Years/Less		All Students		All Students	
		2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Grade 8	District	62	65	19	25	34	36	56	59	66	67
	SECME	89 (198)	82 (233)	70 (5)	32 (19)	*	*	89 (203)	80 (255)		
	Diff	+27	+17	+51	+7	**	**	+33	+21		

*No scores displayed because there were less than 5 students in group.
**Difference not computed because there were less than 5 SECME students in group.

Figure 2.5 indicates a breakdown of the average Florida Comprehensive Assessment Test Norm Referenced Test median percentile scores for students across the school district by curriculum group for District and SECME students in grade 8 for the 2004 and 2005 school years. For the curriculum groups, standard curriculum and Exceptional Student Education (ESE), SECME students, on average, outperformed the District averages. There were fewer than five Limited English Proficient (LEP) students in the SECME program for the years analysed. Standard curriculum SECME students and the 5 ESE students in 2004, on average, outperformed the State median percentile. The values in parentheses indicate the number of SECME students tested. Of note, District scale score averages were below State averages.

Figure 2.6
Excerpt from Table 19: FCAT NRT Mathematics Median Percentile Scores by Ethnicity: District and SECME Students, Grades 6-8, 2004 and 2005

	Grade 8					
	District		SECME		Diff	
	04	05	04	05	04	05
Standard Curriculum						
Black	46	52	70 (27)	59 (69)	+24	+7
Hisp	65	69	89 (136)	88 (122)	+24	+19
White	77	80	98 (21)	94 (28)	+21	+14
All Students						
Black	40	43	70 (27)	46 (79)	+30	+3
Hisp	59	62	89 (140)	86 (131)	+30	+24
White	75	78	97 (22)	94 (29)	+22	+16

Figure 2.6 shows a breakdown of the average Florida Comprehensive Assessment Test (FCAT) Sunshine State Standards NRT Mathematics median percentile for students across the school district by ethnicity for standard curriculum and all students in the district tested in grade 8 for the 2004 and 2005 school years. For all ethnicities, SECME students, on average, outperformed the District averages. Additionally, in 2004, Hispanic and White SECME students, on average, outperform all other ethnicities in the District. The values in parentheses indicate the number of SECME students tested.

APPENDIX A1

2003	
September	Solicit principal approval for schools to participate in research study
October	Distribute pencil/paper TOMRA/TOSRA pretest surveys to schools with directions for administration.
	SECME Coordinators and teachers attend professional development SECME mini-conference at local college.
	SECME students, teachers, and parents attend Mousetrap Car seminar at local university. Observe and collect questionnaire data.
November	SECME students, teachers, and parents attend Bridge seminar at local university. Observe and collect questionnaire data.
December	Observe students during SECME engineering site field trips.
2004	
January	SECME students, teachers, and parents attend Rocket seminar at local college. Observe and collect questionnaire data.
March	SECME students, teachers, and parents participate in Olympiad competition.
May – June	Collect and analyse pencil/paper TOMRA/TOSRA posttest data.
2004 – 2005	
October – March	Re-administer TOMRA/TOSRA pretest surveys to a new group of eighth grade students. Responses collected electronically.
	Observe and collect pencil/paper questionnaire data from parents, students, and teachers attending SECME activities. Conduct interviews.
May – June	Collect and analyse TOMRA/TOSRA posttest data electronically.

APPENDIX A2

A Brief Note from…

District SECME Coordinator
Curriculum Support Specialist
Division of Mathematics and Science Education

Telephone number/Fax number
Email address
School Mail: Location number

November 14, 2003

Dear Participant,

Thank you for coordinating the distribution and collection of the enclosed surveys.

Please distribute the following items to **three (3)** standard curriculum **8th Grade LANGUAGE ARTS TEACHERS to be administered during HOMEROOM only**:

1. TOMRA and TOSRA Booklets
2. TOMRA and TOSRA Answer Sheets
3. Instructions for Administering the TOMRA and TOSRA
4. Parent Letter

All teachers should administer the TOMRA and TOSRA on the same day, at the same time, if possible.

8th Grade SECME students should also be surveyed.

Please collect all completed answer sheets and signed parent letters and place in the enclosed envelope.

I will collect the envelope from you on Wednesday, November 26, 2003 unless otherwise specified.

Once again, thank you for participating in this valuable research for the District SECME program.

APPENDIX B

TOMRA

TEST OF MATHEMATICS-RELATED ATTITUDES
and
TOSRA
TEST OF SCIENCE-RELATED ATTITUDES

DIRECTIONS

1. This test contains a number of statements about mathematics and science. You will be asked what you yourself think about these statements. There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

2. All answers should be given on the separate Answer Sheet. Please do not write on this booklet.

3. For each statement, draw a circle around

   SA if you **STRONGLY AGREE** with the statement;

   A if you **AGREE** with the statement;

   NS if you are **NOT SURE**;

   D if you **DISAGREE** with the statement;

   SD if you **STRONGLY DISAGREE** with the statement.

Practice Item TOMRA

0 It would be interesting to learn about calculators.

0	SA	(A)	NS	D	SD

4. If you change your mind about an answer, cross it out and circle another one.

5. Although some statements in this test are fairly similar to other statements, you are asked to indicate your opinion about all statements.

APPENDIX C

TOMRA

(Test of Mathematics-Related Attitudes)

Page 2

1. I enjoy reading about things which disagree with my previous ideas.
2. Mathematics lessons are fun.
3. I am curious about the world in which we live.
4. Finding out about new mathematics concepts is unimportant.
5. Mathematics lessons bore me.
6. Mathematics is one of the most interesting school subjects.
7. In mathematics, I like to use new methods which I have not used before.
8. I really enjoy going to mathematics lessons.
9. I find it boring to hear about new mathematics concepts.
10. Mathematics Lessons are a waste of time.
11. In mathematics, I like to use new methods which I have not used before.
12. I really enjoy going to mathematics lessons.

Continue to page 3 **OVER**

APPENDIX C continued

TOSRA

(Test of Science-Related Attitudes)

Page 3

1. I enjoy reading about things which disagree with my previous ideas.
2. Science lessons are fun.
3. When I leave school, I would like to work with people who make discoveries in science.
4. I am curious about the world in which we live.
5. School should have more science lessons each week.
6. Working in a science laboratory would be an interesting way to earn a living.
7. I like to listen to people whose opinions are different from mine.
8. Science is one of the most interesting school subjects.
9. I would like to teach science when I leave school.
10. In science experiments, I like to use new methods which I have not used before.
11. I really enjoy going to science lessons.
12. A job as a scientist would be interesting.
13. In science experiments, I report unexpected results as well as expected ones.
14. I look forward to science lessons.
15. I would like to be a scientist when I leave school.
16. I am unwilling to change my ideas when evidence shows that the ideas are poor.
17. A job as a scientist would be interesting
18. In science experiments, I report unexpected results as well as expected ones.
19. I look forward to science lessons.
20. I would dislike becoming a scientist because it needs too much education.
21. I would like to be a scientist when I leave school.

APPENDIX D

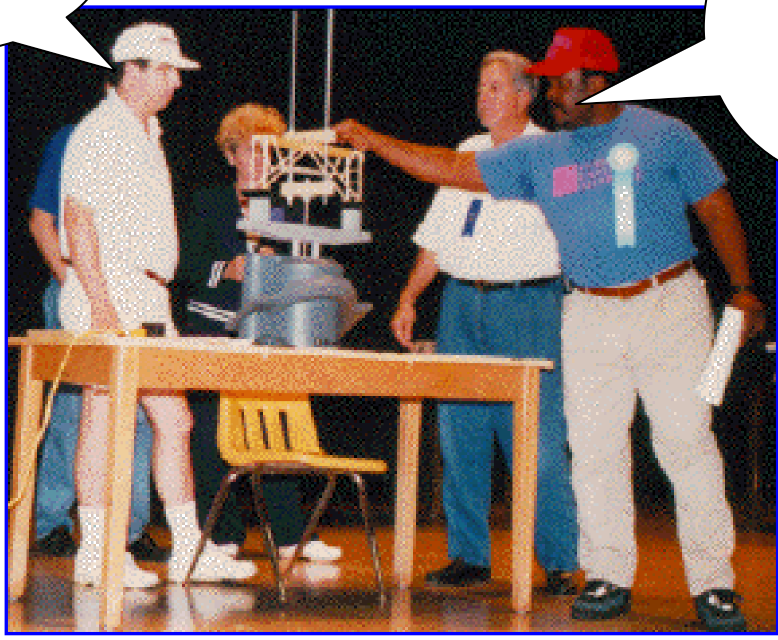
Saturday Design Seminar

<u>BRIDGES</u>

Looking for a Science Fair Project?

Want tips on how to build a winning bridge?

Please copy and distribute to SECME students, teachers and parents



<u>November 20, 2004</u>

FIU – College of Engineering
10555 West Flagler Street

in the

Panther Pit – 2^{nd} Floor

9 a.m. to 12 noon

Directions:
The College of Engineering is located on Flagler Street and SW 107^{th} Avenue

APPENDIX E

M E M O R A N D U M September 12, 2003

TO: Selected School Principals

FROM: Name, Administrative Director
Division of Mathematics and Science Education

SUBJECT: **DISTRICT SECME SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS MINI-CONFERENCE**

SECME's primary mission is to improve the academic achievement of all students in science, technology, engineering, and mathematics. SECME is a strategic alliance of K-12 schools, universities, industries, and government partners dedicated to the professional development of teachers' content knowledge and teaching strategies. If you would like to know more about SECME and/or view the schools that were winners at the 2003 District SECME Olympiad and the 2003 Elementary SECME Festival, that information is available by accessing the SECME website at http://mathscience.dadeschools.net/secme/htm.

In July 2003, 35 teachers from Miami-Dade County Public Schools attended the 28th Annual National SECME Summer Institute at Tennessee State University in Nashville. They have returned with extensive training to support a SECME program at their schools. By way of follow-up and to launch the 2003-2004 SECME activities, **the Division of Mathematics and Science Education's 3rd Annual District SECME Mini-Conference will be held on Saturday, October 4, 2003, at Name Senior High School, 14100 Northwest 89 Avenue, from 8 a.m. to 3:30 p.m.** The agenda will include updates for current SECME schools as well as orientation for new members. Competition breakout sessions and activities that integrate technology, mathematics, and science into the curriculum will be included. Eligible participants who successfully complete the day's agenda will receive a $100 stipend (M-DCPS full-time teachers only) as well as TEC Master Plan Points.

Please make every effort to have **two representatives** from your school attend the mini-conference. This should preferably be your **SECME coordinator and Summer Institute participant** (see attached list) and/or a new or current SECME team member (teacher or counselor). **All participants must pre-register between September 15, 2003, and September 24, 2003, by accessing the website at http://mathscience.dadeschools.net/secme/teachers.asp.**

If you have questions regarding the registration process or this event, contact Mrs. Secondary School SECME Coordinator or Ms. Elementary School SECME Coordinator, Curriculum Support Specialists, Division of Mathematics and Science Education, at 305-995-1767.

APPENDIX F

Division of Mathematics and Science Education

4th Annual SECME Mini-Conference **Agenda**

Local College, North Campus

October 2, 2004

8:00 a.m. – 3:30 p.m.

Registration… Breakfast (Sponsored by: VENDOR) Rm. 9208

Featuring: *Federal Program, Vendor, Local College*

Associate Dean for Natural and Social Sciences

Local College Welcome …………………………....*Chair – Mathematics Department*

Introductions……………………………………...………*Administrative Director*

The Year's Highlights – Old and New...………………*Curriculum Support Specialist*

Today's Agenda……………...…...…………………*Acting District Science Supervisor*

BREAK

AM Breakout

New Schools ………… Rm. 9210

Returning Schools……..Rm. 9208 and Rm. 9209

Host and Presenters Acknowledgments….………………*District Science Supervisor*

Student Opportunities from Local College to National Institute of Technology

LUNCH

PM Breakout Sessions (concurrent) 12 noon – 3:30 p.m.

Elementary Schools (K-5)

World in Motion…....*SECME Teachers*

Rocketry…..….. *Industry & Engineer*

STEM Activities..*SECME Master Teacher*

Secondary Schools (6-12)

S.E.T. w/ Fairchild Tropical Garden......*Informal Science Institution*

GatorTRAX Math……….…………….*University/College*

Mousetrap Car Engineering……….…………*Engineer*

Rocketry……………………………..…..*Industry & Engineer*

Robotics (HS only)……..…………………………*Inventor*

SECME *mATH*letics.……………………..*District SECME*

Evaluations/Teacher Education Credit at breakout sessions

APPENDIX G

GUIDELINES FOR 2005 SECME ENGINEERING DESIGN COMPETITION (MOUSETRAP CAR: CONSTRUCTION AND OPERATION)

ENGINEERING DESIGN COMPETITION REQUIREMENTS:
(Any entry not meeting the following requirements will be disqualified.)

1. The Engineering Design Competition **requires participation in each of these four areas**:
   a. Mousetrap Car, construction and run
   b. Design Drawing of Mousetrap Car
   c. Technical Report on Mousetrap Car
   d. Team Interview with Judges

2. This is a **team competition** and should reflect the coordinated efforts of all members.

3. **Three (3) students must be on each team**. Members must remain the same at all levels of competition (school, state/regional site, and national finals).

4. Each team member is expected to be able to serve as a spokesperson and be fully involved with all aspects of the entry.

5. **A standard mousetrap**--usually about 4.5 X 10 centimeters and weighing about 25 grams—**must be used to build the car**.

6. Components of the mousetrap are: base (on which other components are mounted), spring, bail, locking lever, and bait hook (see component sketch on next page).

7. The mousetrap spring must be the sole source of power. **(You may NOT use rubber bands, CO_2 boosters, or any other agent or element for extra power).**

8. **In design and construction of the car, the original mousetrap spring and wood base MUST remain intact**. These two components may **NOT** be cut or altered in any way— physically, chemically, or thermally. Only the locking lever and bait holder may be removed from the base, if desired. **The bail may be straightened but NOT cut (shortened), added on to, or reinforced. It must remain as a component of the completed car**.

9. The spring must be visible and/or accessible to the judges for inspection.

10. The car must have a minimum of three wheels and can be made as long or short as desired as long as requirement #8 above is met.

11. Cars will be tested on a smooth flat surface. **Distance is measured from the starting line to the farthest point of travel, utilizing a straight line to connect the two points.**

12. **There will be two runs for each car; the better run will be used for final scoring of the mousetrap car's performance.**

(Note: See the page after the mousetrap sketch for Guidelines 13-15.)

13. Two formulas are used to calculate the Performance score for the car run:

$$N = \left(\frac{w}{W}\right) X \left(\frac{D}{L}\right)^2 \quad \underline{\text{and}} \quad F = \frac{N}{N_L}\ X\ 100$$

where:

N....is the score.

<u>To ensure that cars actually perform and not just be small and light</u>,

N=0 if D is <u>LESS</u> than 300 centimeters (for middle school/junior high teams)
N=0 if D is <u>LESS</u> than 600 centimeters (for high school teams)

w....is the mass of the original mousetrap (always taken as 25 grams).
<u>NOTE</u>: At all competitions, this standard value will be used in calculating the Performance score.

W....is the total mass of the completed car in grams.

D....is distance measured in a straight line from the starting point to the stopping point in centimeters. D=2,500 if the car travels 2,500 centimeters or more.

L....is the car's longest dimension in <u>any</u> direction (not necessarily the length) in centimeters, measured with the bail extended or retracted, whichever is greater.*

N_L...is the highest Performance score at the competition site

F....is the final Performance score (to be combined with scores for the Design Drawing, Technical Report, and Team Interview).

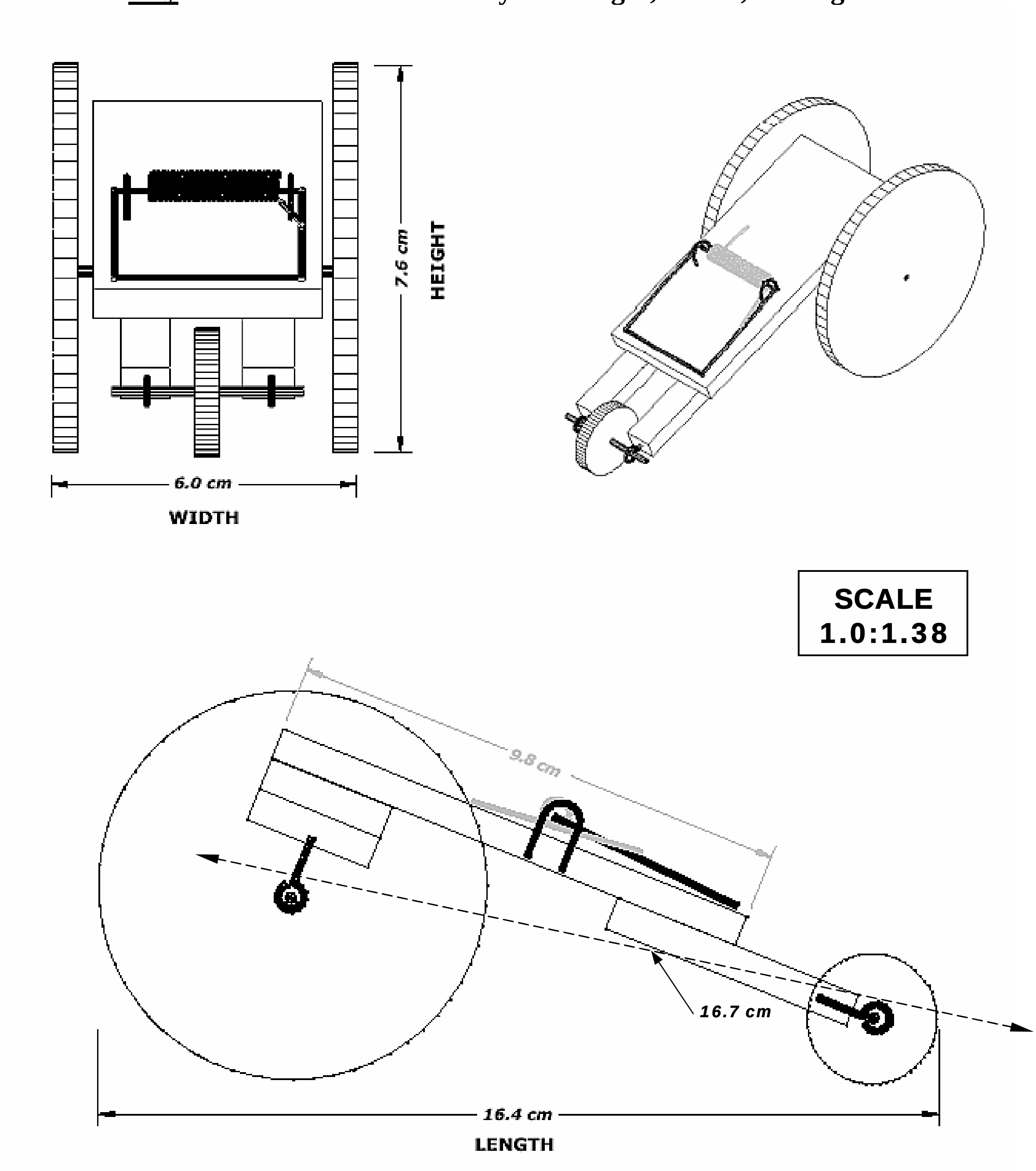
**Judges will measure "L" (see illustration on following page) and "W" prior to the mousetrap car Performance runs. These measurements, together with "D" (determined by the car's run), are used to calculate "N" in the formula above.*

14. Overall Team Score in competition is sum of: 1) Performance (car run) as calculated above (max. 100 points); 2) Design Drawing (max. 50 points); 3) Technical Report (max. 50 points); and 4) Team Interview (max. 50 points). **Thus the maximum total is 250 points**.

15. See pages that follow for guidelines and evaluation sheets on each component of the Engineering Design (Mousetrap Car) Competition.

APPENDIX G continued

Measurement of "L," the Mousetrap Car's Longest Dimension
In Any Direction—Not Necessarily the Length, Width, or Height



"L" is the car's longest measurement along one of the three basic dimensions—length, width, or height—in centimeters with the bail extended or retracted, whichever is greater. The length of the car is defined as the distance from the furthest point at the rear of the car to the furthest point at the front. Likewise, the width of the car is defined as the distance from the furthest point on one side to the furthest point on the other. The height of the car is defined as the distance from the travel surface to the highest point of the car.

L (for this example) = 16.7 cm

APPENDIX H

BRIDGE COMPETITION RULES AND GUIDELINES

1. Materials

a. The bridge must be constructed only from the **official** 3/32-inch square cross-section basswood and any commonly available adhesive.
b. The official basswood may be notched, cut or sanded in any manner but must still be identifiable as the original official wood.
c. No other materials may be used. The bridge may not be stained, painted or coated in any fashion with any foreign substance.

2. Construction

a. The bridge mass shall be no greater than 25.00 grams.
b. The bridge (see Figure 1) must span a gap (**S**) of 300 mm, have a clearance (**C**) of 100 mm above the support surfaces at the center of the span, be no longer (**L**) than 400 mm, have a maximum width (**W**) of 60 mm and be no taller (**H**) than 250 mm above the support surfaces. No portion of the bridge may project below the elevation of the support surfaces.
c. The bridge must be constructed with a slot at least 150 mm long and at least 12 mm wide, centered on the center of the bridge (see Figure 1) to allow the eyebolt connecting the plate to the loading rod to pass vertically through the bridge over the entire length of the slot.
d. The loading plane must be horizontal over the entire 150 mm length of the slot such that the bridge may be loaded at any point (i.e. there are an infinite number of loading points). It must be possible to lower the loading plate (see section 3, below) down from above onto any portion of the slot (a length of 150 mm plus an additional 25 mm on each end).

3. Loading

a. The load will be applied by means of a 50 mm square plate that is 6.35 mm (1/4 inch) thick (see Figure 2). A 9.53 mm (3/8 inch) diameter eyebolt is attached from below to the center of the plate. The plate must be horizontal when it rests on the loading plane. Masses will be supported on a vertical loading rod suspended from the eyebolt.
b. Two edges of the loading plate will be parallel to the longitudinal axis of the bridge.
c. On the day of the contest, judges will decide the exact loading location to be used. It will be the same for all bridges

4. Testing

a. The bridge will be centered on the supports.
b. The loading plate will be placed at the specified loading location.
c. The load will be applied from below, as described in section 3 above.

d. Loading will continue until bridge failure. Bridge failure is defined as the inability of the bridge to carry additional load, or a load deflection of 25 mm under the loading location, whichever occurs first.
e. The bridge with the highest structural efficiency, *E*, will be declared the winner.

E = Load supported in grams / Mass of bridge in grams

5. Qualification

a. All construction and material requirements will be checked both prior to and after testing. Bridges which cannot meet the requirements in sections 1, 2 and 3 will be disqualified.
b. If, during testing of a bridge, a condition becomes apparent (i.e. use of ineligible materials, etc.) which violates any of the contest rules, that bridge will be disqualified.
c. Decisions of the judges are final; these rules may be revised as experience shows the need. (Please check our web site, http://www.iit.edu/~hsbridge, after March 6, 2005, to learn whether any changes have been made.)

APPENDIX I

WATER-BOTTLE ROCKET VEHICLE COMPETITION RULES

The mission is to design a Water Rocket Vehicle capable of reaching the highest altitude possible given specific launch criteria.

1. Maximum number of 5 teams per school, each team consisting 3 students. *(Note: Only 2 teams are allowed to enter in the District Olympiad and1 team is allowed to enter in the Regional Olympiad per school.)*

2. Each team is required to submit a completed entry form and patch design, prior to competition date to qualify for the competition.

3. On the day of competition, but, prior to launch an actual operating rocket with its corresponding technical drawing must be submitted in order to compete in the competition.

Note: At this time each entry must pass a visual inspection and height requirement in order to be eligible to compete. Entries that fail inspection will be given ONE opportunity to make modifications to pass inspection, prior to the beginning of the water rocket launching competition.

4. An overall winner will be judged upon the following criteria (based on 100%):

✈ Hang Time of Rocket	70 %
✈ Patch Design	30 %

5. The objective of the contest is for each team to launch a rocket propelled by water and air and reach a maximum height. The launch angle which can be adjusted from approximately **70 to 80 degrees,** will be kept the SAME for all rockets launching during a particular competition. Each rocket will be launched using 12 ounces of water and at 60 psi of air pressure. The "hang time" of the rocket will be measured using a stopwatch. **The "hang time" is defined as the time from when the rocket leaves the launch pad until the time it reaches the ground**. This measurement will be taken by at least three qualified judges; the average of the judge's times will be used as the final "hang time". The final score for hang time will be calculated based on the maximum hang time recorded during the competition, using the following formula:

$$\left(\frac{hangtime}{\max hangtime}\right)X100$$

APPENDIX J

2005 District SECME Olympiad Schedule of Events

SECME 21ST Century Pioneers – Dreaming Today to Discover Tomorrow

7:45 a.m. **Check-in Projects and Registration (Team Captains, Judges, and SECME Coordinators)**

Projects

Banners *(cafeteria – north side)*
Bridges *(auditorium)*
Brain Bowl *(H.S. rm. H203; M.S. rm. H204)*
Computer *(H.S. rm. K211; M.S. rm. K223)*
Egg Drop *(rm. H201)*
Mousetrap Car *(gymnasium)*
Poster *(cafeteria – south side)*
Water-Bottle Rockets *(rm. H212)*

SECME Coordinators/School Teacher Representative *(office – community school)*
Judges *(teachers' lounge)*

8:15 a.m. **Check-in/Registration Closes**

8:30 a.m. **Opening Ceremonies/Parade of Banners – *Auditorium (everyone)***

9:15 a.m. **Phase I Competitions**

Bridges* *(auditorium)*
Mathematics** *(media center – 2nd floor)*
Brain Bowl** *(H.S. rm. H-203; M.S. rm. H-204)*
Mousetrap Car* *(gymnasium)*
Computer** *(H.S. rm.; M.S. rm.)*
Essays* *(displayed in auditorium foyer)*

10:00 a.m. **Phase II Competition***

Egg Drop* *(Driver's Ed. Range)*

10:30 a.m. **Phase III Competition***

Water-Bottle Rockets* *(track)*

Lunch – Courtyard (available 10:30 a.m. – 2 p.m.)

12 noon **The Yaeger Foundation, Inc., 2nd Annual Bionic Hand Competition* *(auditorium)***

Banners and Posters Displayed (*cafeteria*)*

Please retrieve all competition entries from the morning events prior to 12:30 p.m.

12:30 p.m. **On-site Challenges*****

Unstructured Structure *(gymnasium)*
Windmills – M.S. *(cafeteria)*

2:00 p.m. **On-site Challenges Testing/Demonstrations* *(auditorium)***

2:45 p.m. **Announcement of Olympiad Competition Results – *(auditorium)***

M-DCPS SECME OLYMPIAD PARTNERS/CONTRIBUTORS
Industry/Organization
College/University

***Spectator Events** - *everyone invited to observe.*

****Closed Events** – *only registered competitors allowed in room.*

*****On-site Challenges** - *everyone invited to participate.*

APPENDIX K

Miami-Dade County Public Schools' Division of Mathematics and Science Education
and the
Miami-Dade SECME Alliance, Inc.

S E C M E
A n n u a l   B r e a k f a s t
A w a r d s   B a n q u e t

2005 District Awards Program

Mistress and Master of Ceremonies....

W e l c o m e

Pledge of Allegiance

Acknowledgment of Special Guests
College/University Recognition..Ms. Director, M-DCPS SECME
SECME Parent Award...Ms. Supervisor, M-DCPS SECME
SECME Teachers of the Year...................Ms. Coordinator, Ms. Coordinator, Mr. Coordinator, M-DCPS SECME
SECME Principal of the Year..Ms. Supervisor, M-DCPS SECME
SECME Stars Recognition...Ms. Coordinator, M-DCPS SECME
BREAKFAST
Introduction of Keynote Speaker...Ms. Director

Keynote Speaker......................Dr. Yvonne B. Freeman, Executive Director - SECME, Inc.

Recognition of SECME Students ....Mistress and Master of Ceremonies

Evelyn Ducharme SECME Service Awards

Presentation of Elementary Festival and District Olympiad Awards

Closing Remarks

APPENDIX L

MIAMI-DADE COUNTY PUBLIC SCHOOLS
SECME Bridge Seminar
November 20, 2004

Secondary Student Evaluation

School ______________________________ Grade Level _______

Please Circle:

- Gender: Male Female
- I Consider Myself: African American Hispanic American

  White American Other ____________

1. Do you participate in the SECME **Program at your school?** **Yes** **No**

2. Does participating in SECME keep ***you interested in science?*** ***Yes*** ***No***

3. Does participating in SECME keep ***you interested in mathematics?*** ***Yes*** ***No***

4. Has this seminar made you aware of math/science/engineering careers ? Yes No

5. Are you planning to take higher level science courses? Yes No

6. Are you planning to take higher level mathematics courses? Yes No

7. Were any of the math terms presented today similar to ones presented at your school? Yes No

8. Were any of the science terms presented today similar to ones presented at your school? Yes No

9. How would you rate this seminar?

   Outstanding **Good** **Fair** **Poor**

Participating in a seminar like this makes me feel:

____

____

Thank you for your input !

APPENDIX M

SECME Water-Bottle Rocket Seminar

Teacher Evaluation

Please Circle: SECME Coordinator SECME Teacher

School Level: Elementary School Middle School High School

I have been working with the SECME Program at my school for ______ years.

I teach ___________ grade.

RATINGS: Please rate each statement by circling one number from 4 to 1, where 4 = outstanding and 1 = poor.

Outstanding	Good	Fair	Poor

Overall, this workshop was:

4 3 2 1

I would rate…

- the usefulness of the activities to be implemented in my school's SECME program as

  4 3 2 1

- the instructor's ability to present concepts/activities effectively to be

  4 3 2 1

- the presentation's ability to address concepts in the mathematics and/or science curriculum as

  4 3 2 1

How do seminars like these affect students?

____

How do seminars like these affect teachers?

____

In your opinion, which aspect(s) of SECME positively impact students the MOST?

____

Thank you for your time and input !

APPENDIX N

SECME Bridge Seminar

November 20, 2004

Parent Seminar Evaluation – Secondary School
Please take a moment to complete this anonymous survey so that we may effectively address the mathematics and science needs of all students. Your responses will be used to help improve the SECME program.

Circle your responses:

School level of your child in SECME: Elementary Middle Senior High

Your child's gender:	**Male**	**Female**
Your gender:	**Male**	**Female**
Your ethnicity:	**African American**	**Hispanic American**
	White American	**Other** ____________

RATINGS: Please rate each statement by circling one number from 4 to 1, where 4 = outstanding and 1 = poor.

Outstanding Good Fair Poor

Overall, this workshop was:

4 3 2 1

I would rate…

- the usefulness of the activities to be used with my child to be

4 3 2 1

Comment: ____

How do seminars like these affect your child? ________________________________

How do seminars like these affect parents? __________________________________

Which gender, if either, do you believe performs better in mathematics (males or females)? _____

Which gender, if either, do you believe performs better in science (males or females)? _______

Do you believe that certain ethnic groups perform better in science? **YES** **NO**
If yes, which one? _______________ Why? ________________________________

Do you believe that certain ethnic groups perform better in mathematics? **YES** **NO**
If yes, which one? ______________ Why? _________________________________

Thank you for your input!

APPENDIX O

«Principal», Principal
«School»
«School_Address»
«CityStZip»

Dear Middle School Principal:

Permission is requested for approximately 80 sixth through eighth grade students from your school to participate in a research study. The purpose of the research is to assess the SECME pre-college engineering program's effects on students' attitudes and achievement in science and mathematics. Parent permission will be requested for student involvement in one or several of the following data collection methods:

- Completion of a 15-minute, pre- and post-attitudinal survey
- Interviews
- Student observations in classroom settings
- Release of mathematics and science academic grades
- Release of FCAT/norm-referenced test scores
- Release of mathematics/science course selections

The pre- and post-attitudinal surveys will be administered in October and April, respectively. Samples of students will be selected for 5-10 minute interviews and observations in their classroom setting between October and December 2003. This contact will be non-intrusive; it will not disrupt classroom lessons. The student sampling will not be identifiable and confidentiality will be maintained. Participation in this study will be beneficial in providing information regarding the effects of pre-college programs such as SECME on students' attitudes towards academic subjects. This will allow for the enhancement of program qualities that have a positive effect on student attitude and achievement in mathematics and science. **Please indicate below whether you will give permission for your school to participate in this valuable research study and return it by fax, <Fax number>, Attention: Ava D. Rosales.**

Enclosed is a copy of my approval letter from the Research Review Committee of the Miami-Dade County Public Schools (M-DCPS), approval number 976. Should you have any questions, feel free to contact me at <Telephone number>.

Sincerely,

Ava D. Rosales, Curriculum Support Specialist
M-DCPS Division of Mathematics and Science Education

Enclosures

Yes. Permission is GRANTED to participate: **No. Permission is DENIED to participate:**

Principal's Signature Date Principal's Signature Date

APPENDIX P

Dear Parent/Guardian:

Permission is requested for _**<Name>,** attending **<School>,** to participate in a research study. The purpose of the research is to assess a precollege engineering program's effects on grade eight students' attitudes and achievement in science and mathematics. Participants will be asked to be involved in one or several of the following data collection methods:

- Completion of a 15-minute, pre- and post-attitudinal survey
- Interviews
- Classroom observations
- Release of mathematics and science academic grades
- Release of FCAT/norm-referenced test scores
- Release of mathematics/science course selections

The pre- and post-attitudinal surveys will be administered in August and April, respectively. Samples of students will be selected for 5-10 minute interviews and classroom observations will take place between October and December. This contact will be non-intrusive; it will not disrupt classroom lessons. The student sampling will not be identifiable and confidentiality will be maintained. Participation in this study will be beneficial in providing information regarding the effects of precollege programs on students' attitudes. This will allow for the enhancement of program qualities that have a positive effect on student attitudes and achievement in mathematics and science. Please indicate below whether you will give permission for the above-named child to participate in this valuable research study, and return it to <Teacher> at <School> by Thursday, October 30, 2003.

I will be the person responsible for this research. Should you have any questions, feel free to contact me by mail at the M-DCPS Division of Mathematics and Science Education, <Street Address>, or by telephone at <Telephone number> or e-mail at email@emailaddress.

Sincerely,

Ava Rosales, Educational Specialist

Division of Mathematics and Science Education

Yes. Permission is GRANTED to participate:	No. Permission is DENIED to participate:
________________________________	________________________________
Parent/Guardian's Signature	Parent/Guardian's Signature