EXPLORING FACTORS AFFECTING SUCCESS AND PERSISTENCE OF UNDERREPRESENTED MINORITIES IN UNDERGRADUATE SCIENCE, TECHNOLOGY, ENGINEERING, AND MATHEMATICS (STEM) MAJORS

by

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Abstract

This was a study to explore the persistence and success of underrepresented minorities in undergraduate science, technology, engineering, and mathematics (STEM) majors. Specifically, the effect of the precollege STEM curriculum on the preparation and persistence of undergraduate STEM students was examined. National statistics continue to illuminate the need for increasing the number of underrepresented minority students attaining STEM degrees, emphasizing that a large percentage of these students have enrolled in these majors. The persistence of traditional and nontraditional students was considered in the study. The following research questions were used to determine the types of data that was collected and analyzed: (a) How does the precollege STEM curriculum affect the persistence or non-persistence of underrepresented minorities in undergraduate STEM majors? (b) How can curriculum reform motivate underrepresented minority learners to persist to undergraduate STEM degrees? (c) What types of instructional methods aid in nontraditional STEM students persistence and degree attainment? A qualitative approach was identified as the appropriate methodology to address the research questions, and the data collecting tool, consisting of semi-structured interviews gave rich descriptions into the STEM students' preparation, persistence, and success. Findings from this research will help to improve understandings about underrepresented minorities' precollege STEM preparation and its effect on their postsecondary STEM success, thus adding to the growing body of knowledge about improving underrepresented minorities' persistence and success in STEM programs. The findings of this study suggest that the most important factor that aids underrepresented minority success and persistence in undergraduate STEM programs is their precollege STEM preparation

Dedication

I first dedicate this project to my loving Lord Jesus who helped me through this long and tedious process. Secondly, to my deceased parents David and Eudalyn Blair, who have always been my encouragers, and wanted to see me succeed. They taught me the humility, dedication, and hard work that I take to my work and studies. This project is also dedicated to my brothers and sisters especially to my faithful sister Orlene, who "held up my hands" when they got weak, and cheered me on. My parents, especially my mother, taught me from an early age, that nothing is impossible to me if I believe. I love you.

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CHAPTER 1. INTRODUCTION

Introduction to the Problem

Science, technology, engineering, and mathematics (STEM) fields have become very important to United States' security, health, and competitiveness. A diverse pool of scientists and researchers is needed to fuel America's economy (National Academy of Science, 2009). To strengthen the competitiveness of the United States (U. S.) with other developed countries, there must be more equality in the economic standards of its citizens (Davis, 2003). Degree attainment in STEM fields means higher paying jobs for Americans (Davis, 2003). Allowing underrepresented minorities access to higher paying jobs found in the STEM fields is one way of boosting the economy and ensuring that Americans hold the highest-paying positions in the country (Davis, 2003).

There is an increased emphasis in this nation to improve science and technology in its schools and colleges. During the past ten years, issues associated with the number of underrepresented minorities in STEM majors, have been at the center of numerous discussions (Robinson, Rousseau, Mapp, Morris, & Laster, 2007, para. 3). Similar discussions centered on the number of doctoral scientists and engineers employed in colleges and universities in the 20th century, noting the lack of underrepresented minorities within these fields. A lack of underrepresented minorities in our colleges and universities is a result of the declining number of this people group holding advanced degrees in the STEM fields. Robinson et al. (2007) noted the lack of diversity in STEM fields, stating that business personnel have a strong desire to make significant commitment to diversify the workplace. In a technological society, diversifying the workplace implies that underrepresented minorities must have a vital role. Postsecondary STEM education programs need to be addressed in reference to underrepresented minorities to see how or why those minorities are not as actively involved in STEM programs.

Economic growth throughout the world since the industrial revolution has occurred mainly because of the “pursuit of scientific understanding, the application of engineering solutions, and continual technological innovation” (National Academy of Sciences, 2007, p. 41). One of the privileges of a democratic society is equal opportunity for all people. African Americans, Hispanics, and Native American students seem to be missing that privilege in their pursuance of STEM degrees. To maintain its economic growth and global competitive focus, the United States must invest in postsecondary and adult education, and assure that colleges and universities train a mixed population of students in science and technology. Without this type of investment, the U. S. may continue to involve and utilize only a small percentage of its talented population as scientists and researchers.

For more than three decades, America’s colleges and universities have made determined efforts to create racially diverse campuses (Anderson & Kim, 2006; Trenor, Yu, Waight, Zerda, & Ting, 2008). However, although most institutions effectively attract and enroll underrepresented minorities, this people group remains underrepresented in the STEM pipeline (Anderson & Kim, 2006; Trenor et al., 2008). This apparent lack of underrepresented minorities attaining degrees in STEM fields will undoubtedly lead to a lack of underrepresented minorities with needed STEM degrees in the workforce, including America’s colleges and universities (Jackson, 2003; Vest, 2003). Hence, the workforce will continue to be undiversified. Addressing the problem now will help to alleviate it in the 21st century United States of America.

Background of the Study

The postsecondary education system in America still reflects inequalities. This inequality is more pronounced in the STEM fields. The National Science Foundation (2005) has proposed that precollege STEM students undergo an intensive or "rigorous" STEM program. However, most of the underrepresented minorities in our colleges and universities are from low socioeconomic backgrounds and attend schools where they are less likely to participate in a rigorous precollege STEM program as proposed by the National Science Foundation. According to Anderson and Kim (2006), African Americans, Hispanics, and low socioeconomic whites, are less likely to attend schools where they participate in a rigorous science curriculum. However, while in college, these underrepresented groups are held at the same expectations or learning standards as their peers who participated in a more advanced curriculum. This being so, a culturally based curriculum is required at the precollege and postsecondary levels to mobilize these students through the STEM pipeline. A culturally based pedagogy, when used, will address culture, economics, race, and gender (Gay, 2000) and will captivate the students' imagination, making the program compatible and motivating to the learners. As Yager (1996) so aptly contends, "Science when presented in a way known to scientists, will be inherently interesting and appropriate for all learners" (p. x). Motivation at any or every level of learning fosters success. Our students will only be able to thrive in a global economy, when equipping them with the knowledge and skills necessary to do so, takes precedence in our schools, colleges and universities. The equipping must begin prior to their enrollment in college courses.

Although graduates in STEM fields are decreasing among all races, genders, and cultures (Tsui, 2007), literature confirms that the number of underrepresented minorities attaining bachelor's degrees in these fields is decreasing more severely (Anderson & Kim, 2006; Cassel & Slaughter, 2006; Tsui, 2007). In addition, African American, Hispanic, and Native American students begin college interested in majoring in STEM fields at similar rates to those of white and Asian-American students (Adelman, 2006), but do not persist to degree attainment. Adelman further noted that most of the students who did not persist dropped out of college or changed majors in their second or third year of college. As America's diversity—both racially and ethnically—grows, educational institutions need to develop methods to retain these students to degree attainment. Finding the link between students' obstacles and students' success, may be one solution to the persistence of underrepresented minorities in college STEM majors. Additionally, success in STEM programs means that institutions of higher education are meeting the needs of both their students and the society. STEM success will provide more STEM workers – educators, computer scientists, engineers, biological and chemical scientists, researchers, as well as better role models for younger underrepresented minority students (Cassell & Slaughter, 2006; Davis, 2003). Role models serve as mentors for their younger counter-parts, thus helping them to develop an appreciation for the STEM fields.

To ensure that American workers are the best prepared in the world and for the 21st century, educators need to prepare all students to excel in their chosen academic fields (Davis, 2003). Building a diversified STEM workplace "is increasingly important to sustaining the nation's productivity and economic strength," (George, Neale, Van Horne, & Malcom, 2001, p. 2). When underrepresented minorities change their STEM majors to other majors, or drop out of college after their first or second year (Adelman, 2006), it does not assure that higher education institutions are motivating a diverse majority of their student population to persist to degree attainment in their chosen fields of study. Rather, such activities seem to indicate the institution's failure to support and retain its students.

As noted earlier, a rigorous precollege curriculum contributes to students' persistence in the STEM fields (Adelman, 2006; Anderson & Kim, 2006). Also noted is that students from low socioeconomic backgrounds are less likely to attend high schools where they pursue a rigorous curriculum (Anderson, 2006, p. 13). In light of those findings, this qualitative study will solicit college students' prospective on the effect of their precollege and undergraduate STEM preparation on their persistence and success in undergraduate STEM courses. The students' opinions on other factors like the effects of faculty support and teaching pedagogy on students' STEM persistence will be included in the study. The exploratory data collected for this exploratory qualitative design study will be analyzed thematically.

Statement of the Problem

The number of underrepresented students graduating from postsecondary institutions with bachelor's degrees in the STEM fields is decreasing, thus decreasing the number of post-graduate STEM degrees and narrowing the diversity gap for qualified STEM workers in the workplace (Robinson et al., 2007). The problem is that certain minorities are underrepresented in the ranks of graduating STEM majors (National

Academy of Science, 2009). As a result, sectors of the twenty-first century workplace will be undiversified, since the number or percentage of minority workers will be limited. A number of underrepresented minorities, who enroll in the STEM fields, change majors, do not complete their degrees within six years of enrolling, or drop out of college during or after their second year of enrollment. Although it is documented that underrepresented minorities enroll in STEM majors at similar rates as students of other races and cultures (Adelman, 2006; Anderson & Kim, 2006), it still needs to be determined why these students are not persistent to obtaining bachelor's degrees at similar rates as their Asian American and European American peers. Therefore, the problem to which this study is directed is the persistence and success of underrepresented minorities in postsecondary STEM majors.

Significance of the Problem

Much emphasis is placed on the premise that females and underrepresented minorities are underrepresented in STEM positions in the workplace (Cassell & Slaughter, 2006; Davis-Butts, 2006; Rogers, 2005). Although several reasons for this underrepresentation can be found in literature, no study has addressed how or whether the alignment of the high school curriculum with the college curriculum, could affect the persistence and success of underrepresented minorities in college STEM courses. This study will foster an understanding on how the knowledge, skills, standards, and content learned by high school STEM students affect their undergraduate persistence and degree attainment, and therefore add a significant body of knowledge to the research on the persistence and success of underrepresented minorities in STEM majors.

Results from the 2005-2006 ACT National Curriculum Survey (ACT) revealed a substantial difference between high school science teachers and postsecondary science instructors' perceptions and expectations of what is most important as prerequisite skills and knowledge for success in postsecondary science courses. For example, whereas postsecondary science instructors rated process and inquiry skills or inquiry standards as most important, high school science teachers rated content standards as most important (ACT, 2007). The indication exists that while high school, college bound students focus on content standards, the requirements needed for college success are inquiry and skill building standards. The results of this study will have practical applications for assisting postsecondary institutions interested in retaining underrepresented minorities adopt new methods and/or strategies of helping their STEM students develop the skills and knowledge necessary to persist in their STEM programs and later in the workplace. In addition, the results of this study will help curriculum makers and educators focus on knowledge, skills, standards, and content that are transferable from high school to postsecondary STEM education, and to the workplace.

Purpose of the Study

The purpose of this explorative qualitative study was to discover why some underrepresented minority college students are successful in undergraduate STEM majors. Hence, this study sought to understand some of the factors that might have led to their persistence and success. In particular, the research focused on curriculum factors of the precollege and undergraduate curriculum, curriculum reform and precollege and postsecondary teaching pedagogy. It was believed that the use of the curriculum to foster greater learning experiences would lead to persistence and degree attainment among underrepresented minority learners. The report of this study was based on the descriptive data that emerged.

An inductive approach was employed for this exploratory qualitative study, because information gathered from participants was formed into categories or themes. Creswell (2006) describes the inductive process in a qualitative study as one in which one builds from the data, to broad themes, to broad explanations or theories (p. 63). In addition, Creswell (2008) states that a qualitative research tends to address research problems that require the researcher to explore a problem about which little is known, and get a detailed understanding of a central phenomenon (p. 51). Since there were no studies found that addressed the impact of the high school STEM curriculum on the persistence of postsecondary STEM learners, it was contended that little is known about the problem. The data collected by this qualitative research was not intended to prove or disprove any hypothesis attained in prior studies therefore, the data was collected inductively (Bogdan and Bilken n. d.). Face-to-face interviews were the instruments used for the data collection.

Rationale

Several studies have addressed the topic of underrepresentation of minority learners in STEM programs (Adelman, 2006; American Council on Education, 2009; Anderson & Kim, 2006; National Academy of Sciences, 2009). However, in a diverse technology society as the United States, the question of why is there a decline in the number of underrepresented minorities attaining degrees in the STEM fields was yet to be answered. There were no studies found that directly addressed how the knowledge, skills, structure, content or other factors of the high school STEM curriculum affected student persistence in undergraduate STEM courses. Hence, the reason or importance of this study was to address that problem.

According to one theory of adult learning, adults have learning needs closely related to changing social goals, are problem centered, and will therefore learn something when there is an immediate need to learn it (Merriam, 2003). Considering the rapid increase in adult undergraduate enrollment (American Council on Education, 2009), it seems that adults have a need to learn. Some of the needs may be job related, or connected to financial stability or self-improvement. For whatever the reason, all learners should be afforded the opportunity to succeed in his or her chosen field. Since most underrepresented minorities' goal for having a college education is to change the economic status of their family, and to have a sense of self worth, (Cassell & Slaughter, 2006), those who chose STEM majors should be motivated to attain a degree in the field of their choice. Hence, based on the apparent lack of persistence and low graduation rate of these people groups, the need arises for further investigation.

The need and impact that the lack of diversity will have on STEM professions in the workforce, and in society, have being well documented (Johnson, 2003; National Academy of Science, 2009; Rogers, 2006; Shireman, 2003). Therefore, the focus of this study was to explore the alignment of the precollege curriculum's knowledge, structure, skills, and standards with the undergraduate curriculum, the contribution that such alignment of the curriculum made or could make on students' persistence, and the effect that a curriculum reform could have on the persistence and degree attainment rates of twenty-first century underrepresented minority learners.

Research Questions

Exploring the problem of underrepresented minorities in STEM majors included data from undergraduate STEM majors presently enrolled in STEM classes. The perceptions and opinions of traditional and nontraditional students were vital to this study. Therefore, the following questions guided the investigation:

a. How does the precollege STEM curriculum influence the persistence or non-persistence of underrepresented minorities in undergraduate STEM majors?

b. How can curriculum reform motivate underrepresented minority learners to persist to undergraduate STEM degree attainment?

c. What types of instructional methods aid in nontraditional STEM student persistence and degree attainment?

Nature of the Study

An exploratory qualitative study was conducted to explore the impact that the high school or precollege curriculum had on the persistence, success, and/or degree attainment of underrepresented minorities in undergraduate STEM majors. An interview protocol was employed to solicit information from STEM learners for the study. The semi-structured interview, which was developed by the researcher, was designed to elicit information from successful STEM learners about the effectiveness of their high school and undergraduate curriculum on their STEM persistence and success, the instructional strategies that are most effective, and the effectiveness of college instructors' support. With participants' permission, the interviews were audio taped and then transcribed. In order to get details, notes including direct quotes of the participants were taken.

Definition of Terms

The following definitions clarify the concepts and terms used in this study:

Adult education. Lecture or correspondence courses for adults; usually not engaged in formal study. A learner who continues learning in a postsecondary setting at age twenty - one or older is an adult receiving adult education.

Curriculum. Includes goals for student learning; content to be learned; the sequence or order in which concepts are presented; the learners; instructional methods and activities; instructional resources; evaluation or methods of assessment; and adjustments to teaching and learning processes, based on experience and evaluation.

Dependent Student. One who depends on parents or other relatives for support while enrolled in college.

Minority. The part of a population that differs from others in some characteristics, and are often subjected to differential treatment (*Merriam-Webster's Dictionary,* 1984). For this study, minority refers to African Americans, Hispanics, and Native Americans.

Nontraditional students. For the purpose of this paper, this group represents students usually age twenty-four or older, who did not enroll in a postsecondary institution immediately after their high school graduation, or who re-enrolled at age twenty-four or older.

Persistence. To continue without change in function or structure. For this study, persistence is to be enrolled in an undergraduate STEM major after six years of enrollment. A student who did not graduate from a STEM field in a six-year period, is not enrolled in a STEM field after the six-year period, or has changed to a non-STEM field, is not persistent, and therefore is not a persister.

Post-secondary education. (a) A formal instructional academic, vocation, and/ or continuing education program with a curriculum designed for students who have earned a high school diploma or its equivalent (Oregon Network for Education Glossary of Terms). For this study, postsecondary education is a program offered at an educational institution that leads to a degree completion.

STEM completers. Students who earn a degree in a STEM field over a six-year period (IES, 2009).

STEM major. The areas of study pertaining to mathematics, statistics, computer/ information science, computer programming, electrical, chemical, mechanical, civil or other engineering, engineering technology, electronics, natural resources, forestry, biological science (including zoology), biophysics, geography, interdisciplinary studies including biopsychology, environmental studies, physical sciences including chemistry, and physics (Anderson & Kim, 2006, p. 21).

Success. The completion of a college degree (Tinto and Pusser, 2006). Underrepresented minority students who graduated from an undergraduate STEM degree program without changing majors, have attained success.

Underrepresented. To be inadequately represented (*Merriam-Webster Dictionary*, 1984). For this study, underrepresented refers to a group or groups of students that are not equally mainstreamed into the STEM pipeline in the United States.

Assumptions and Limitations

It was assumed that the participants' responses were honest and accurate when responding to the interview questions. However, as typical to most studies, there were limitations. Creswell (2008) defines a limitation as the potential weaknesses or problems of design of the study that could potentially reduce the study's validity and scope. One such limitation was that this research was conducted in a predominantly Black university where responses from other learners of other cultures were limited. Since responses came from predominantly African American students, the data may not have been a reflection of the majority of underrepresented minorities in STEM majors.

The researcher's personal biases might also limit the accuracy of the study. Patton (1990) argues that there are limitations to how much can be learned from what people say, therefore, to understand the complexities of many situations, direct participation in, and observation of the phenomenon of interest may be the best research method. Answers to questions need to be verified so as to avoid misunderstanding and biases, which is another limitation in qualitative data. Since interview questions in a qualitative study give rise to other questions, as was the case in this study, the effect of interview limitations should be minimal.

Theoretical/Conceptual Framework

The work of three authors formed the theoretical foundations of this study. In their report, Tinto and Pusser (2006) discussed the existing theories and literature on student persistence and success. They noted that despite the many years of research and effort made in student persistence and success, the rates of college completion in the United States have not changed appreciably over the past twenty years (p. 2). The discussion focused on the persistence and success rate of low-income students in comparison to high-income students, noting that the need exists for an institutional model of action which will impact institutions to improve student persistence and success. Tinto and Pusser (2006) further discussed conditions for student success. Among the conditions discussed were institutional commitment, institutional expectations, support, feedback, and engagement. This model of institutional action for student success which explained how postsecondary institutions can influence student success was very relevant to the present research on student persistence and success.

In the second article, Owens (2009), reviewed the United States' current science education policies and discussed ways in which those policies could be changed to enhance student achievement. The author focused on precollege science education, an action that made her work valuable to this study.

Organization of the Remainder of the Study

Science and technology have become extremely important for developed and developing countries in the twenty-first century. These countries depend on graduates of STEM fields to fill the pool of researchers, scientists and technologists that are needed. The United States, which has become a multicultural society comprising of various ethnic groups, has the potential to strengthen its economic competitiveness with other developed countries, by strengthening its STEM pipeline. However, this can only be effectively done if the postsecondary institutions of the United States make a conscious decision to educate and train an increased number of minority citizens and residents in STEM professions. In addition, attention needs to be centered on the large percentage of nontraditional students who are enrolling in colleges and universities across the nation, as these students could help to increase the persistence, success, and graduation rate of underrepresented minority STEM students.

Chapter 2 of this study is the review and discussion of relevant and recent literature on topics related to the study. The topics reviewed in this chapter include Tinto and Pusser's model of institutional action for student success, Owens's model for improving science achievement, the importance of STEM, persistence or non-persistence, undergraduate curriculum reform, precollege curriculum reform, standards-based STEM curriculum, diversity in STEM education, nontraditional learners in STEM majors, and effective teaching strategies for STEM success. The review reflects the rationale for its use. The methodology, along with the rationale for the qualitative design chosen is outlined in chapter 3. The participants, sample selection, method and types of data collection and the instrument used are outlined. The analysis plan for the qualitative data from the interview protocol, are also presented.

Chapter 4 presents the results from the data collected as outlined in chapter 3. The information is arranged in themes, and similarities in participants' experiences are noted. Consistent with a qualitative design, and in order to develop an understanding of the meaning of the explored phenomenon, the results are presented in a narrative form. Chapter 5 is a summary of the study. It provides the findings and recommendations, which are based on the literature that was reviewed. A full assessment of whether and/or how the study addressed the problem is also included.

CHAPTER 2. LITERATURE REVIEW

Introduction

The purpose of this study was to explore factors affecting the persistence of underrepresented minorities in undergraduate STEM majors and in particular, it explored the effect of the precollege curriculum on the students' postsecondary education success. The undergraduate population in the American postsecondary or higher education institutions is increasing rapidly and adult underrepresented learners make up a significant proportion of that population. However, in spite of the increased accessibility to postsecondary education the degree attainment rate especially among underrepresented minorities in the STEM fields has not increased. In fact, the number of underrepresented minorities obtaining bachelor's degrees has declined significantly (Adelman, 2003; American Council on Education, 2009). Like the domino effect, underrepresented minorities are dismally outnumbered in the workforce specifically in the STEM fields.

Literature review typically appears as detailed independent works or as brief introductions to reports of new primary data. The following plan for reviewing and identifying resources explains how appropriate research that informed the study was identified and grounded the research questions. Full documentation of search activities, including the recording of names of database, search terms, abstracts of articles retrieved, and dates on which articles were retrieved was done. Scholarly, peer-reviewed literature, pertinent to the research topic and questions was the primary focus. However, materials that were deemed relevant, but were neither scholarly nor peer-reviewed were evaluated for their relevance and potential, and were used in this study.

Cooper, (1998), states that the literature review can attempt to integrate what others have done and said, criticize previous scholarly works, build bridges between related topic areas, identify the central issues in the field, or all of these. Chandler (2004) has identified five functions that a literature review can serve. The review can indicate what researchers in the field already know or do not yet know about the topic, generate major questions in the topic, provide background information for the non-specialist reader seeking to gain an overview of the field, ensure that new research avoids the error of some research, and demonstrate the researcher's grasps of the subject. This literature review sought to (a) indicate what researchers know or do not yet know about the topic, (b) generate major questions in the topic, (c) provide background information, and (d) demonstrate the researcher's grasp of the subject.

The literature research is a qualitative research document needed to study the problem (Creswell, 2008). Literature has focused on gender differences and on traditional students' persistence and success in the STEM fields (Eddy & Lester, 2008; Laursen & Rocque, 2009; Xu, 2008), but there is a lack of literature that explains the disparity within these people groups. The focus of the literature for this paper was the concern for the disparity of underrepresented African Americans, Hispanics and Native American students pursuing undergraduate degrees in a STEM major, how the alignment of the precollege and undergraduate STEM curriculum could affect students' persistence and success, and the impact their persistence could have on the United States' future workforce. Studies emphasizing diversity in precollege and college STEM majors and STEM curriculum, curriculum reform and its effect on adult student motivation and success, and teaching and learning strategies for adult learners, were reviewed.

Information from these sources reflected discussions or arguments for and/or against the topic. After a critical evaluation, the best materials found were selected. Comparisons were made between various research findings, and a critical evaluation of the authors' results served as the basis for this selection.

Based on Creswell (2008) model, the literature was organized into important themes, and the themes highlighted for easy recognition. In a thematic review of the literature, the researcher identifies a theme and briefly cites literature to document this theme (Creswell, 2008). This thematic review identified gaps in the research, pinpointed limitations in the literature, discussed important findings, and suggested future directions that research in this area could take. It further discussed how this research will build on and/or depart from previous research on the topic, and what contributions the research will make to the area been studied.

Tinto and Pusser's Model of Institutional Action for Student Success

Tinto and Pusser (2006) proposed a model for student success in which they discussed the need for postsecondary institutions to take action in increasing the rate of student persistence and success. The model focused on institutional action as it shapes events within the institution, noting that institutions have little effect over certain external events that influence student success. The authors contended that most of the research and literature concerned with student persistence and success focus on events that are outside of the institution. The authors posit that student learning is the basis of student success and persistence, and made it the focus of their model. The model outlined five conditions that promote student success.

The first condition, and that which the authors deemed foremost, is the institutional commitment. As contended by the authors, “institutions that are committed to the goal of increasing student success, especially among low-income and underrepresented students, seem to find a way to achieve the end” (Tinto & Pusser, 2006, p. 6). The institutional commitment is a reflection of the institutional leadership hence, leadership must be willing to invest resources in those aspects of institutional functioning that impacts student success directly or indirectly (Tinto & Pusser, 2006). Leadership in Tinto and Pusser’s (2006) model involves the support of deans, department chairs, and vice presidents, which will in turn directly impact the willingness, work, and cooperation of faculty and staff.

Along with the use of institutional assessment and accountability procedures resulting in the differential allocation of funds to support various programs that promote student success, administration or leadership can promote incentives and rewards, as well as faculty and staff development programs (Tinto & Pusser, 2006, p. 16). For example, incentives and rewards could be given to faculty and staff who add addition time and effort to their full workloads to be involved in collaboration activities like learning communities and the development of interdisciplinary curricula that takes place outside of their field or departments. Further, the model proposed involvement in faculty development programs, noting that higher education faculty is the only faculty in education that is not trained or required to be trained to teach their own students. According to the authors, very few postsecondary institutions require faculty who teach first year students, to undertake or be involved in staff development programs.

Second, the authors contended that high expectations are a condition for student success, and argue that institutions too often expect too little of their students, especially during their first year of college. Further, institutions will often hold differing expectations for their students based on ethnicity and gender. This can be seen in terms such as, "remedial, nontraditional, and first-generation" used by faculty to describe groups of students, or the way in which students of color are treated by faculty (Tinto & Pusser, 2006, p. 6).

According to the authors, the expectation climate of an institution sets the tone for the expectations of faculty, staff and students. For example, the institutional expectation climate shapes and determines how individual responds to each other and to the demand placed on their time. The expectations expressed by faculty for student performance impact the quality of the students' effort and work. In addition, when the institution expects more of its faculty in terms of teaching, and provides support for teaching, faculty will be more inclined to place a greater emphasis on teaching (Tinto & Pusser, 2006). Based on the model, the expectation climate, although shaped by many people, should be first and foremost the responsibility of the president or chancellor of the institution. Without his or her commitment and high expectations for especially low-income and underrepresented students, there will not be substantial improvement for student success over time (Tinto & Pusser, 2006).

Support is the third condition in Tinto and Pusser's (2006) model for student persistence and success. The model proposed that financial, advising, academic, social and personal support, are the types of support that are more widely employed. According to the authors, work-study programs are very effective since these programs help students pay for college as well as getting them involved with other members of the institution. In their discussion on advising, which is the fourth condition in the model, the authors suggested that the institution should employ the advising program or programs that allow all students to obtain accurate advice when it is needed.

Like advising programs, academic support programs are many and varied. However, Tinto and Pusser (2006) contended that supplemental instruction programs that are provided to students in a specific course are particularly effective because they allow students to immediately apply the support provided to succeeding in that particular course. Another support program that is supported by this model is the developmental learning communities, which require the content and activities of the linked courses to be coordinated in such a way that what is being studied in one course can be applied to other courses in the learning community (Tinto & Pusser, 2006, p. 13). Other forms of academic support proposed by this model are summer bridge programs, and freshman seminars. These support programs are particularly helpful to low-income and academically underprepared students.

Social support programs such as freshman interest groups, ethnic studies, and students clubs, are very important to underrepresented students who attend predominantly white institutions. In addition to the social support they provide for especially the new students, they provide smaller supportive community of peers for these students. At the centers where students congregate, knowledgeable peers can help new students navigate their way through the unfamiliar institution. Mentoring programs - a more formal type of support, matches new students with peers, faculty, and/or administrators. The attachment lasts for the entire first year of college and provides role models, guidance, and some long term relations for these students (Tinto & Pusser, 2006).

As in the other types of support, feedback—usually referred to as assessment—takes many forms. The assessment proposed in this model are those that are employed during the first semester as part of an early warning system, and those that are used in the classroom to provide information about students performance to both the students and the institution. The use of student portfolios, for example, provides both the student and the institution descriptive feedback which improves student learning and success (Tinto & Pusser, 2006, p. 14).

Finally, engagement or involvement has proven to be one of the most important factors that influenced student success. The greater the degree of student engagement with peers, faculty and other people on the campus, the more likely they are to persist. Further, even among those who persist, those students who are most engaged experience greater learning gains (Tinto & Pusser, 2006).

These observations are very important for institutions which serve a large body of commuting students, since the extracurricular activities, residential programs and clubs would yield little benefit for such students. This model proposed that the classroom should be used to give students the opportunity to engage with faculty and peers. Teaching pedagogies such as cooperative learning, collaborative learning, and problem-based learning were recommended by the authors. These "pedagogies of engagement" can take the form of learning communities which require advance planning and scheduling (Tinto & Pusser, 2006, p. 15).

The observations and suggestions in Tinto and Pusser's (2006) model of institutional action for student success are believable. The report cited researchers and/or theorists who have made considerable contributions to research on student achievement and success, persistence and success, attrition rates, academically underprepared students, underrepresented students, ethnic and low-income students, and institutional support. The components of this model are useful to both traditional and nontraditional students, underprepared college students, and underrepresented minority students. In addition, this model is helpful to the postsecondary community because it did not only discuss the theory of student persistence and success, but it presented a model of action to solving the problem.

Owens Model for Improving Science Achievement

Owens (2009) addressed the science achievement of K-12 students in the United States. The author contends that students in the United States fail to learn science for one or all of three reasons:

> [a] Our system of education ignores the research about how students learn science; [b] teachers are aware of the research but fail to implement it in their classrooms; or [c] the standards, curriculum, and education policy of the United States are not conducive to effective science teaching. (Owens, 2009, pp. 49 – 50)

Owens (2009) maintained that the current education policy in the United States, which is strongly influenced by the No Child Left Behind Act of 2001, has greatly influenced what is taught in the classroom and how it is taught (p. 49). Keeping in line with Gallagher (2007), and Moreno and Tharp (2006), the author contended that students enter the classroom with different skills and thinking and learning styles, therefore a number of instructional strategies should be implemented in the classroom. Owens (2006) noted that inquiry, which is the method of learning science by doing, is foremost in helping students learn science. This method of science teaching and learning is also recognized the National Research Council (2007).

Other pedagogical approaches suggested by the author are peer-to-peer interactions and incorporating the students' prior knowledge or experience of how the world works, into the learning of new concepts. Gay (2000) favored peer-to-peer interaction in the classroom as it not only improves student learning, but helps to create diversity in the classroom. Incorporating the student prior experience is well supported by Dewey's theory of experiential learning.

Owens (2009) noted that because each state is allowed to develop its own science curriculum, science assessment, and set its own assessment standards for proficiency in science, proficiency in science has a different meaning for each state. That may account for the fact that when proficiency in science is assessed at the national level, only 18% of twelfth graders perform at or above the proficiency level (p. 50). The author's statistic is confirmed by Loomis and Bourque (2001), who further stated that in addition to the multiple choice questions, the National Assessment of Education Progress (NAEP) assesses student engagement in actual science investigations.

According to Owens (2006), science education in grades K-8 is of low priority in some schools, since in many states, schools are not held accountable for proficiency in science in these grades. In addition, because teachers of grades K-8 do not receive adequate training in the development of science content knowledge and effective science teaching strategies, they may devote less time to the teaching of science. The author posits that such actions could account for the low science achievement by high schools students. Bybee (2006) alluded to Owens' (2009) theory when he stated that how students are taught, directly influences what they learn.

Owens (2009) suggestions for improving science achievement in K-12 included implications for science education and policy. She proposed that:

a) For teachers to implement science teaching strategies that will correlate into student learning, the teachers must receive adequate pre-service and in-service training.

b) Significant advancements need to be made to the national and state science curriculum so that a greater emphasis is placed on the quality rather than on the quantity of knowledge to be learned.

c) Science curriculum developers and policy makers should collaborate with other countries that are having greater successes in their science education programs.

d) Changes in curriculum and standards reform should begin in the earlier grades.

e) When formulating science education policies and curriculum, current research and examples of effective science pedagogies from countries having high levels of achievement should be used.

f) Policy makers should consider a more nationalized approach to science education as that would eliminate some of the inconsistencies in the present K-12 science education program.

Although further research is warranted to determine the applicability of Owens (2009) research to the success and persistence of postsecondary students, the researcher confirms the theories of other researchers cited in this study. Adelman (1999, 2006) linked a rigorous high school STEM curriculum with postsecondary success, and added that low-income and underrepresented students are less likely to participate in a rigorous STEM curriculum. However, Gorski, (2009) posits that a good curriculum will give all students the types of higher-order thinking skills that are usually reserved for the wealthier students. Owens (2009) noted that at the national level only 18% of twelfth graders obtained proficiency rating in science. Further, results from the 2005-2006 ACT curriculum survey noted that there is a substantial difference between precollege and postsecondary instructors' perceptions and expectations of what is most important as prerequisite skills and knowledge for success in postsecondary science courses. Based on the findings of other researchers, Owens (2009) research is valuable to this proposed study.

Importance of STEM Programs

Many reasons exist why it is important that everyone gain equal access to the STEM pipeline. One needs only to think about what his/or her life would be like without the technological developments of the previous century. As the result of the investment in research and STEM education programs, transportation, communication, agriculture, education, health, defense, and jobs, have all changed the face of America and other developed countries. Many diseases have been suppressed or eliminated by vaccines, we now rely on such things as healthy foods, laptop computers, hip replacement, and world travel to name a few (National Research Council, 2003). However, these advancements are not unique to the American society. Global competition in science and engineering talent has intensified, and it would be to America's advantage to enroll a higher percentage of its students in STEM programs (Council on Competitiveness, 2004).

Improvement in the areas of science, technology, engineering and mathematics is one way to ensure that America remains competitive in the twenty-first century (Anderson & Kim, 2006). Scientific and technological innovations have economic gains. For example, "hip-fracture prevention in postmenopausal women at risk for osteoporosis saves the country $333 million annually" (National Research Council, 2004, p. 54). According to Pascarella and Terenzini, (2005) higher education graduates typically enjoy social and economic advancement regardless of their background and socioeconomic status.

One reason for degree attainment among underrepresented minorities is the desire for economic advancement. Pay rates for jobs in the STEM fields are among the highest or are the highest in the United States (National Center for Education Statistics [NCES], 2009). Due to the low enrollment, persistence, and degree attainment rate of underrepresented minorities, they will have limited access to the economic status they desire. Ensuring that a larger number of underrepresented minorities attain STEM degrees will put them in better positions to help the country compete with other nations like China and Japan in fields such as computers and energy production, and allow them to obtain jobs with competitive salaries.

Persistence or Non-Persistence

A common theme exists that many students in the United States, show a lack of persistence to complete an undergraduate STEM degree (Adelman, 2006; American Council on Education, 2009; Mendez, Buskirk, Lohr, & Haag, 2008). This lack is a major concern since many researchers are concerned about the future of science and technology in the twenty-first century United States. Concern regarding the ability of

America to maintain its competitiveness in the world's economy has renewed the nation's interest in STEM education (NCES, 2009, p. 1). This renewed interest resulted in the National Academy of Science (NAS), the National Academy of Engineers (NAE), and the Institute of Medicine, coming together to issue a report asking that the STEM pipeline be strengthened across the educational arena, from primary to postsecondary education (NCES, 2009). The report made recommendations for the enhancement of the STEM teaching force and for increase in the number of students pursuing STEM degrees.

Enhancement of the STEM teaching force would attract underrepresented STEM teachers at both spectrum of the STEM education pipeline—precollege and the tertiary—since there is a concern that this people group is underrepresented as instructors in higher education. Data about the percentage of STEM educators in tertiary institutions is however limited. In addition, information about the number of students who complete STEM degrees is available from agents like the U.S. Department of Education, for example, but according to Anderson and Kim (2006), little is known about undergraduate students' STEM progress. The progress of undergraduate STEM majors during their course of study is not tracked or monitored, therefore the number of underrepresented minorities who did not persist to degree attainment is not known. What is known however is that the number of underrepresented minorities persisting to degree attainment is dismal due to the alarming increase of minority dropout rates (American Council on Education, 2009).

A study by the Institute of Education Sciences [IES] (2009), addressed students who entered the undergraduate STEM fields, their persistence and degree completion several years after enrollment in postsecondary education, and who persisted to completing a STEM degree after enrollment or entrance into a STEM field of study (pp. 1-2). This study revealed that of the 73 percent of students who declared a STEM major at the beginning of their postsecondary education, 36 percent did not remain enrolled in, or graduate from a STEM field. Interestingly, some students who graduated with a STEM degree did not declare a STEM major at the beginning of their college year, while others who were undecided about their majors switched to a STEM major, and enrolled in a STEM field during the sixth year of their postsecondary enrollment. Some students switched majors within the STEM fields. For example, students who initially enrolled in physical science, later enrolled in the biological / agricultural sciences, and mathematics majors switched to engineering/engineering technologies. Among the students who declared and entered a STEM major at the beginning of their college education, 37 percent were STEM completers, 7 percent were STEM persisters, 27 percent switched to a non-STEM field, and 28 percent left college without earning a degree, or even a certificate (IES, 2009, pp. 10-11). Although this study provided some relevant data, it focused on all postsecondary education students entering college and persisted to seven or eight years after entry, but not directly on underrepresented minorities. The relevant data painted a picture of the overall persistence of the nations' undergraduate STEM learners. It further confirmed that there are nontraditional learners pursuing STEM degrees.

Another common theme that exists among researchers is that success in college STEM programs is somewhat dependent on students' preparation before they are admitted into college programs (Adelman, 2006; Anderson & Kim, 2006; Cassell & Slaughter, 2006; Horwedel, 2006; NCES, 2009). Adelman (2006) contends that, "a student's high school record dominated by a high academic intensity curriculum provides the most significant momentum prior to college entry. It's far more important than what the student looks like," (p. 17). Although literature reveals that students' precollege STEM preparation affects their persistence in college STEM courses, researchers have not looked at the alignment of the skills, knowledge, content and structure of the curricula, how that might affect students' persistence, and if non-persistent students are given the same opportunity to participate in the same type of curriculum. Exploring whether there is a link between those factors of the students' precollege and undergraduate STEM curriculum, and whether it affects students learning, would enhance the literature in this area of study.

Anderson and Kim (2006) found that students, who earned bachelor degrees in STEM majors in the spring of 2001, and over a four-year period, were significantly better prepared for postsecondary education than those who did not earn a degree but were still enrolled after four years of enrolling. Hence, both the level of precollege preparation the student receives and the intensity of the precollege curriculum can prolong or shorten, the students' degree completion time. Nearly 42 percent of the completers in STEM fields studied what is considered as a highly rigorous STEM curriculum in high school, compared to only 18 percent of non-completers (Anderson & Kim, 2006, p. 11). Solidifying these findings, is the NCES (2009) report which contended that students who took higher-level mathematics courses to include, trigonometry, and calculus, for example, were most likely to persist to STEM degree completion. In that model the number of STEM degrees earned was consistent with the STEM field chosen. Majority of the students in the model were not persistent in mathematics, chemistry and engineering as they were in the physical sciences. Underrepresented minorities are less likely to pursue a rigorous precollege STEM curriculum due to factors like school and family demographics (Adelman, 2006), and are therefore less likely to attain their degrees over a four year period.

It is further argued that persistence or non-persistence in undergraduate STEM majors is dependent on the age of entrance, and on whether the student is dependent or independent. According to such studies (Adelman, 2003; 2006; Anderson & Kim, 2006), students entering postsecondary education at age nineteen or younger, are more likely to complete their degree over a six-year period, than those entering postsecondary education at age twenty to thirty years or older. The study inferred that younger STEM majors are more likely to be dependent and will complete their degrees in less time than the older independent students will. However, Mendez, et al. (2008) found that age did not have a significant effect on STEM persistence. According to these authors, STEM students who have a high cumulative Grade Point Average (GPA) after their first year of college are more likely to persist to degree attainment. Since the age of the students who obtained a high GPA was not determined, it may be fair to assume that both traditional students—age eighteen to twenty-four years— and nontraditional students—age twenty-five years and older— can earn a high cumulative GPA after their first year of college.

Additionally, younger and dependent students were more likely to switch to a non-STEM major if changing, while the nontraditional students leave college without switching majors or graduating (Mendez et al., 2008). Considering that the majority of the undergraduate student population falls within the age group of twenty-five to thirty-four, (IES, 2009) and are independent, there is a larger number of older or nontraditional students leaving college before graduating. Some of these students have declared STEM majors and should they persist, could strengthen the STEM pipeline in tertiary institutions and in the workforce.

Undergraduate Curriculum Reform

Some of the United States most prominent business organizations have joined to express their concern for the United States to maintain its competitiveness in science and technology in the twenty-first century and beyond (Business Roundtable, 2005). The organizations are concerned that the United States may lose its scientific and technological supremacy if taken for granted. It must become a priority to everyone in the United States to ensure that "students and workers have the grounding in math and science that they need to succeed and that mathematicians, scientists, and engineers do not become endangered species in the United States" (Business Roundtable, 2005, p. 14). In the committee's quest to double the number of students who attain undergraduate STEM degrees by 2015 a number of recommendations were made. They included: (a) building of support for making STEM improvement a national priority, (b) up-grading the K-12 math and science teaching to ensure higher student achievement, (c) building the awareness of the importance of more students studying and obtaining degrees in the STEM fields, (d) and making special effort to incorporate those in currently underrepresented groups. (p. 10-11)

Many suggestions regarding the best way to accomplish these goals were given, but the suggestion that is pertinent to this study stated that a curriculum should be adopted that includes rigorous content as well as real world engineering and science experiences that enable students to gain a working knowledge of their field of study. In so doing, students will build excitement for their field of study, and will know what they need to do and learn in order to work in the field.

The recommendation to adopt a curriculum that includes real world experiences is in line with the theory that adults learn through prior experiences (Mezirow, 1991). A curriculum that includes students' prior experiences may be just what nontraditional adult learners need to improve their learning and persistence in higher education. According to Tinto and Engstron, (2003), it was argued for sometime by educational observers, that student involvement is important to student education and persistence. Focusing on students' experiences is one way of getting adults involve in the curriculum that they are expected to study, which can be a motivating factor towards their persistence.

Another concern voiced by postsecondary educators is that many learners age 18 – 25, who enroll in adult programs, lack the skills necessary for the program or course, (The American Institutes for Research, 2006). The report stated that skill deficiency of adult learners is intensified by the fact that adult education programs are "not adequately prepared to provide numeracy education to a diverse student population that brings different needs, interests, skills, behavior, and attitudes toward numeracy" (p. 1). This indicates that adult education in the United States is not prepared to meet the needs of its growing diverse population, some of whom are underrepresented in the U.S. society. Further, it casts a level of doubt on whether the students' attitudes towards numeracy, is the result of the attitude they acquired during their precollege education.

Educators have recognized for over a century that the curriculum and pedagogy of the schools are not benefitting many students and they have taken steps since the nineteen thirties, to redesign the curriculum (Kridel, 2002). Dezure, Lattuca, Huggett, Smith, and

Conrad (2006), further contend that in the latter decade of the twentieth century, there were significant changes in the undergraduate curriculum, and that in the 1980's there were increasing urgency for college curriculum reform. This led to reports like *A Nation at Risk* in1983 and *Integrity in College Curriculum* in 1985, (Dezure et al., 2006). These reports highlighted deficiencies in the curriculum studied by American students, its effects on how and what students learn, and warns against its impact on the American society. Critics stated that graduates of the curriculum, which lacked accessibility, quality, and coherence, were unable to solve problems, effectively perform both written and oral communication, make ethical decisions, work in teams, and effectively interact with diverse groups (p. 510).). Hence, strides were again taken in the curriculum reform to improve what undergraduate students learned and how they were taught.

In order to ensure that STEM degree seekers have the skills needed for the twenty-first century workforce, curriculum reform leaders focused on "broadly defined competencies" (Dezure et al., 2006, p. 510). This move left room for criticism however, as discourses soon began to arise regarding the lack of depth of the content in specialized areas, and the fragmentation of the curriculum. According to Dezure et al., (2006) critics argued that the undergraduate curriculum lacked coherence and was over laden with isolated bits of information. In the pursuit for continuing the curriculum reform process, learning communities for undergraduate courses were developed. These have proven to be effective in enhancing students learning and persistence (Dezure et al., 2006, Tinto & Engstrom, 2003).

This type of curriculum reform, however, is not custom fit for all learners. For, as Gutek (2004) so aptly puts it, the school curriculum does not have everything there is to know, it includes some but not all areas of knowledge. The curriculum contains what knowledge curriculum makers deem worthwhile for society and society's members. The areas of knowledge contained in the curriculum may not have the content required by several learners who need some kind of knowledge. Hence, how the curriculum affects the learner, depends on the knowledge it contains, and the challenges it brings to the learner. Employers are seeking graduates with strong skills and abilities in problem solving, teamwork, communications and leadership, but also with strong mastery of the content (Jones, 2004; Marx, 2008). The curriculum that is developed to address and include multicultural learners, will address all the above contents and/or concepts. It will further address the needs of the learners as they affect society.

The shift from curriculum content to broad competencies and collaborative learning groups as proposed by some curriculum reformists may not fit the learning styles of underrepresented learners. Hence, although the curriculum was reformed to include diversity studies, it is not mentioned that the knowledge, skills, content, and structure of the curriculum are relevant to the lives of underrepresented minority independent students, who are more likely to be affected by it. Some of these undergraduate students are employed in STEM fields, and accordingly, will have different learning needs than their younger more privileged peers. Such students need a curriculum that is relevant to their needs and experiences.

If the structure of the curriculum reflects changes over the years, then one would expect that the very nature of instruction and/or pedagogy especially in the area of multiculturalism would have been changed or transformed (Nieto, 1999). However, although engineering practices continue to evolve, engineering education has not changed significantly since the 1950s (Lang, Cruse, McVey and McMasters, 1999). Controversy centers on the relevancy and efficacy of engineering programs and the opportunity was afforded stakeholders to help universities design a curriculum that meets desired outcomes. Industry involvement in undergraduate STEM programs would help students gain the industry experience needed for their STEM academia ranks while giving them the motivation to persist.

While undergraduate curriculum reform is acknowledged, there is much concern about the content, efficacy, and effectiveness of the STEM curriculum. In addition, the curriculum, if effective, must be effective to all groups of students. Presently included in the undergraduate STEM curriculum reform, are lecture and laboratory section integration, collaborative problem-solving groups or calculus reform, undergraduate research students working on research projects with faculty, collaborations among institutions, business, and industry, and interdisciplinary studies. However, the literature does not reveal the impact of the curriculum on the education and persistence of underrepresented minority learners.

While educators will agree that the above curriculum reform factors enhance learning, according to Gorski (2009) however, a multicultural curriculum must contain content that is complete and accurate, and acknowledge the contributions and perspectives of all groups (Lang et al., 1999). For example, African Americans, Hispanics, and Native American students will be more motivated to learn a curriculum that acknowledges the contributions made to the field of study by men and women from their race and/or culture. In collaborative and/or discussion sessions, biases are minimized when each member group can for example, "connect" with the scientist, whose work is being examined.

Precollege Curriculum Reform

One of the themes developed from this literature review is that students who participated in a rigorous precollege or high school curriculum, performed better in their college STEM courses than those who did not (Adelman, 2006; Anderson & Kim, 2006). This section of the literature review explored the precollege curriculum and its effect on underrepresented minorities STEM persistence. According to Gorski, (2009), a good curriculum will give all students, including low-income students, the types of higher-order thinking curricula that are usually reserved for the wealthier students.

In 1920, the Progressive Education Association (PEA) found that all secondary education students were instructed in conventional college preparation programs although only one out of six of these students continued on to postsecondary education, (Kridel, 2002). In order to address the needs of the non-postsecondary education students, while linking the high school curriculum with that of the college curriculum, the Commission on the Relation of School and College—the Aikin Commission—was initiated. The commission selected a number of schools and gave them permission to revise their curriculum. That effort by the commission, encouraged collaborations between participating high schools and colleges that would permit experimentation of the secondary school's curriculum (Kridel, 2002). Students from schools that used the experimental curriculum were given college entrance privileges.

During the PEA experimentation, each school staff developed its own curricular program. Course subjects were not presented as they were usually taught. Instead, the subjects were organized around themes that were significant to the learners. Findings from the study revealed that students from schools that were involved in the PEA project – the progressive schools, performed comparably better academically, culturally, and artistically, during the schools' evaluation process, than students from schools that did not participate. Further, the progressive schools students were not impaired in their postsecondary preparation. This study proved that education institutions could experiment with the curriculum while meeting the needs of their learners thus, helping college-bound students to be well prepared for college (education.stateuniversity.com).

As the needs of employers become more complex however, and the college-bound population increased and became more diverse, the need once again arose for further curriculum reform. In the 1960's the Science Curriculum Reform programs, featuring the top down structure, where the reform began at the twelfth grade, and progressed down to the elementary grades was developed. During that time students focused on projects at the National level. Another reform of the nineteen-nineties, featuring the bottom-up structure, which first addressed the elementary grades, and progressed to the middle grades, through to high school, was developed (Bybee, 2005). Although this reform increased academic scores in some subjects (Blosser, 1989), it lacked higher order learning objectives and recommendations were made to include higher-order learning objectives in the curriculum.

Several frameworks for curriculum influenced the United States districts and states' reform for science during the nineteen-eighties and nineties. Such reforms had advantages of high levels of implementation, as well as the disadvantages of "lower levels of real program reform" (Bybee, 2006). In many instances, because of limited time and funding, new perspectives on science and technology, learning theory, program design, and new materials were not developed and incorporated into the curriculum. School districts adopted textbooks, but teachers did not participate in staff development that would update them in science and development content and strategies (Bybee, 2005; Tobin & Dawson, 2006). Commercially published curriculum materials were widely used, partly because curriculum reformers or developers failed to acknowledge that the teachers needed additional training. Because textbooks were the determinants of the nineteen sixties curriculum reform, the reform effort was unsuccessful (Yager, 1996). The emphasis on textbooks did not allow for the creativity needed in the classrooms. Teachers were limited to the routine and activities of textbooks. This curriculum called the science, technology, and society (STS) model was neither implemented, nor taught effectively hence, students could not relate the theory to the practical. It is not known what impact the STS curriculum reform had on underrepresented learners and how it affected their persistence in STEM courses. However, it is relevant to this study because of the discussions of factors that affected the skills, knowledge, structure and content achieved by the learners of this curriculum before entering postsecondary education or the workforce.

By the mid-twentieth century, America's employers were seeking workers who could relate the theory to the practical. For a science and technology curriculum to be successful, students would need to apply the knowledge of the content to the practical demands of the workplace. To do this, students have to be able to think critically and not rely on the contents found in textbooks. As Bloem and Klooster (2007) citing Noddings, (2006) state, "critical thinking occurs when people diligently apply skillful reason, but do so on matters of moral and social importance" (para. 2). Up unto the twentieth century the precollege curriculum was not written or implemented to help students think critically, and did not contain the content, skills and tasks that would help students to think critically on things that would improve society. It did not help them learn how their interests or what they are interested in can be of moral and social importance. For example, some students who complain that they hate mathematics would readily do the statistics on the winnings and positions of their favorite football game. A precollege STEM curriculum that incorporates the skills and content of other subjects, as well as the experiences and statistics about the students' culture, sports and music hero, for example, might prove helpful in stimulating STEM interest. A curriculum that readily meets the interests of such students would greatly enhance students' understandings of the course content (Bloem & Klooster, 2007). Critical thinking skills learned and practiced at the precollege level can be transferred to undergraduate courses and to the workplace.

Standards-Based STEM Curriculum

Another theme that arose from the literature that was reviewed was that of standards-based curriculum. Standard-based curriculum was introduced in the American education system largely for economic reasons (Tucker, 2002). For many decades of the twentieth century, only a minority of the American population needed higher than an eighth grade' education to do the jobs that were available. Additionally, American businesses became aware that they could get the same work done for less if the work was done in foreign countries – mainly in the Asian countries. Hence, thousands of jobs which required low levels of literacy began moving overseas (Tucker, 2002). This created the need for jobs requiring higher levels of education.

State governors became concerned about the many jobs that were been lost to "low-wage countries", and business leaders were realizing that America's future required skilled and educated workers. The business leaders petitioned the governors to take the initiatives to give professional educators more flexibility and control over the education resources. In return, the states educators would commit to be held accountable for the results (Tucker, 2002). The governors' decision left state educators scrambling for a curriculum that would produce the best results. Some states focused on goals, where schools that met the goals were rewarded, while those that did not faced consequences. Others chose the educators accountability model, where academic standards were adopted and tests matching these standards were mandated. Still others selected the ministry of education standards, which required that "high and explicit standards" are set for all students up to a certain grade (Tucker, 2002, p. 2319). Non-professional educators, however, stressed the importance of standards, assessments, and a system of rewards and consequences, believing that such model would give public educators incentives for increasing performance.

Some politicians proposed one curriculum for the nation, but in spite of efforts made by these politicians to create national education standards, each state chose to set its own standards. Reviewers and critiques of the standards movement, (McLaughlin, 1999; Tucker, 2002), criticized the standards curriculum as having much width and little depth. Textbooks publishers published books and other materials that omitted materials that would promote students' understandings. Although many topics were crammed into a single textbook, the topics, which were superficially treated, omitted conceptual material necessary for student understanding (Tucker, 2002).

Claubaugh and Rozycki (1990) posit that the curriculum can be organized in a number of ways, including logical, pedagogical, disciplinary, and institution (p. 497). According to the authors, one of the forces driving the structuring of this organization is determined by how knowledge is structured. For example, the structure may be reality based or socially based. Typically, in America's precollege public education, the institutional structure is most commonly reflected in the curriculum by grade level, and passes all the way down to the chapters in a book. Hence, curriculum reform reflects a hierarchical structure where the logic is based on the institutional and student needs for education and control (Claubaugh & Rozycki, 1990). The present technological society, however, requires another paradigm, which will reflect the involvement in, and the learning and application of science, technology, engineering, and mathematics.

Federal education reform programs like the No Child Left Behind (NCLB) Act and the states' effort to redesign precollege education, have provided reform foundations that may be built on (The Education for Innovative Initiative, 2005). However, because educators are preoccupied with the task of preparing students to pass high stakes districts and states' tests, as well as trying to meet educational standards, this action has resulted in decreased students' motivation and learning especially in the STEM courses. (Noddings, 2006). Additionally, many STEM education teachers are not sufficiently equipped or prepared to make the link between the theory and the practical, or classroom knowledge and the STEM workplace usage therefore, the only way for reformists to ensure that the students connect the link is to build such skills into the curriculum. By using pre-written lesson plans which are written into the curriculum, and setting out specific skills that the students should learn, these teachers are able to transfer the skills to their students.

Pre-written lesson plans, are linked to standardized tests and cover the basic skills that the students should know. When the plan is followed and taught by teachers the students are likely to be taught the basic skills, knowledge and content that is required for that grade. Some teachers complain however that the pre-written lesson plans leave little or no room for ingenuity and creativity (McLauhghlin, 1999). Hence, while standards reform occupies its place in the educational paradigm, new paradigms are necessary to make or connect the classroom–workplace linkage, which would help students make the connection between the theory and the practical. That link is necessary because educators are and will be pressed to offer a curriculum for life that engages students in addressing real world problems, issues important to humanity, and questions that matter (Marx, 2006, p. 7). That type of curriculum will seek to improve the linkage between high school and postsecondary or higher education, and will foster diversity in education, to include STEM education at both the precollege and postsecondary levels.

Postsecondary science educators in many states argue that their states' high schools' curriculum standards are not adequately preparing their students for the college level skills, knowledge, tasks, and content required for their persistence to undergraduate degree attainment (ACT 2007). If the states standards are not focused on college readiness, it may be safe to assume that the assessments that are designed to measure the attainment of the standards do not consider college readiness. Precollege teachers are required to teach the content and skills dictated by the state standards (ACT, 2007). Based on the ACT 2005 – 2006 survey many of these teachers belief that their schools are adequately preparing their students for college readiness. At the same time, the post-secondary instructors believe that the states are doing a poor job in that area. It is not surprising then that while postsecondary science instructors rate science process and inquiry, knowledge and skills most important for students' college readiness, high school science instructors rate science content as the most important (ACT, 2007).

In 2004, the National Science Teachers Association (NSTA) released a statement recommending the use of inquiry as a method of helping students learn and understand the processes and content of science. However, when an inquiry-based instruction curriculum is juxtaposition with a test-preparation curriculum, instruction in the science classroom in most situations, favors the test-preparation curriculum (Falk & Drayton, 2004). Hence, while the inquiry-based curriculum was taught in some schools and classrooms, in others the test-preparation curriculum took preeminence. Where the teaching pedagogy focused on both the process of inquiry and the covering of state and national content standards, the students achieved both required objectives (NSTA, 2004). Therefore, students would be better prepared for postsecondary education if the curriculum and teaching pedagogy focused on inquiry as well as test taking skills.

Diversity in STEM Education

Diversity is defined as "differences in how people think" (Driefus, 2008). People may look the same but think differently. Similarly, they may look quite different, and think similarly. The definition of diversity also includes people's identity groups such as ethnicity, race, age, and sexuality (Clayton-Pedersen & Musil, 2002; Driefus, 2008; Johnson & Scafide, 2002). The term also takes into account how academic institutions meet their educational objectives. For example, whereas the legality over affirmative action in admissions was designed to remedy past discrimination, it now rests on the interest of the state in reaping the educational value of a diverse student body (Clayton-Pedersen & Musil, 2002). Hence, diversity in the educational institutions carries a different meaning from that of the workplace.

STEM education presents learners with different ways of seeing and solving problems. Likewise, people from different backgrounds have different ways of seeing and solving problems. When placed in a diverse learning environment, STEM students learn and benefit from other individuals of different backgrounds and life experiences. This learning experience is doable both at the precollege and postsecondary or higher educational levels. Driefus, (2008), quotes Page as saying, "breakthroughs in science increasingly come from bright diverse groups" (para. 10). This statement is evidence in the interdisciplinary work done in scientific research. Scientists, mathematicians, technologists, social scientists and others will work together on a single project, valuing the different talents, experiences, and ideas that each researcher contributes. Underrepresented minorities in postsecondary institutions need to experience this type of diversity among their peers and faculty, since during their precollege years, many of them, and specifically those in STEM programs, attended schools that were undiversified. Further, in the twenty-first century, underrepresented minority students will continue to enroll in predominantly white institutions at higher rates than enrolling in what were or are historically Black higher education institutions (Johnson, 2005). Encouraging diversity in the college classroom could be the motivation for persistence among underrepresented minorities in STEM programs.

In many colleges and universities majority of STEM educators or professors (80% to 82%) are retiring White men. Most of the remaining professors are from countries outside the United States and are not familiar or are partially familiar with the United States educational system or the education of underrepresented minorities (Kuenzi, 2008). Hence, underrepresented minorities in STEM fields may not experience diversity in their classroom learning experiences. The affirmative action of 1965 was executed to ensure that diversity existed in education and employment. However, affirmative action is not reflected in the United States STEM education and employment pipeline. According to the Congressional Research Service (2008), diversity among STEM educators is necessary in both precollege and postsecondary educational institutions.

When students learn in a diversified precollege classroom, it better prepares them for learning in a diversified postsecondary program of study. They are more likely to study a curriculum that is rigorous and skills oriented (Kuenzi, 2008). Accordingly, learning in a diversified college environment helps to prepare students for a diversified workforce. If colleges and universities recruit and educate a more proportionate number of underrepresented STEM majors in STEM degree programs at all levels of postsecondary education, the STEM diversity gap would be narrowed at all areas of society (American Council on Education [ACE], 2009). Postsecondary institutions must endeavor to include in their recruits displaced workers, veterans, and other nontraditional learners who are returning to college for degrees or certificates. Many of these students are already enrolled in colleges across the United States (ACE, 2009).

Diversifying STEM in postsecondary education and the workforce have been the interests of postsecondary institutions like the University of North Carolina, Purdue University, University of Massachusetts, and the Commonwealth Alliance for Informational Technology Education (ACE, 2009). These institutions target underrepresented groups, and nontraditional students. While some institutions are using adult learning methods like prior work experiences, previous learning assessment, computer based instruction, and accelerated learning to bring diverse talent into the STEM industries, others like America' Veterans to Tennessee Engineers program promise employment for its graduates on completion of their engineering degree. Acknowledging that adult learners have financial needs, the "NEW- STEM program in Alabama" compensates students who are persisting to degree completion (ACE, 2009). Other STEM education initiatives train and certify retirees and displaced workers to teach in K-12 classrooms.

Such programs diversify both the American student body and the curriculum, while helping to ensure a more diversified education system. Since some of these programs are also designed to improve the quality of STEM education in both high school and postsecondary classrooms, high school STEM students may be better prepared for their postsecondary or higher education experiences in the future. Students will be exposed to STEM mentors of similar culture, race, and background, thus having positive role models. Further, underrepresented high school students can be exposed and directed to STEM professions and/or careers through programs that allow high school students to work with college faculty mentors. STEM education such as those that enhance awareness among nontraditional learners and underrepresented groups, and give them different pathways to education in STEM fields will increase diversity in STEM education institutions and in the workforce.

Nontraditional Learners in STEM Majors

It is estimated that nontraditional students represent over 60 percent of the higher education population, and that over 65 percent of these are thirty-years old or older (Counsel for Adult and Experiential Learning (CAEL), 2002). These students are displaced workers, homemakers, or employed persons desiring to get an undergraduate or advanced degree. However, because the existing studies on the persistence of minority in college STEM majors were conducted with traditional students – that is, students of age eighteen to twenty-four years, peer reviewed literature about nontraditional students in STEM could not be found. In light of an information-driven U.S. economy, which led to the increasing demand for scientists, technologists and other STEM field workers, having a college degree has become increasingly important in the workplace. Hence, nontraditional students who want to share in the success of the present economy are increasingly pursuing college degrees. Some of these students are working in STEM industries and could be motivated to earn STEM degrees. Further, some have training and certificate in STEM fields, while others might have opt out of the STEM education during their introductory undergraduate courses in science and mathematics, which were designed to select out the best and most committed students and discard the rest (National Academic Press, 2007). For whatever reason, this group of students has become the new majority in the undergraduate college population (CAEL, 2002).

Nontraditional students have different needs than those of traditional students, and these needs reflect the differences in the knowledge, experience, skills, and attitudes of these adult students (CAEL, 2002). Postsecondary institutions wanting to attract and retain these workers need to develop principles that are effective for serving adult learners. Some of the identified needs of these workers include different kinds of information about their educational options, the flexibility of the institution in curricular and support services, academic and motivational advising which support their life and career goals, and the incorporation of their experiences and work-based learning into their education (CAEL, 2002). Although many U. S. colleges and universities have become responsive to the educational needs of nontraditional learners, other institutions have not yet realized the students' academic potentials.

According to the theory of adult learning, adults learn best when they are able to plan and evaluate their own learning (Merriam & Caffarella, 1999). Whereas traditional college students may be content with the institutions' pre-planned academic planning and assessment, nontraditional learners have the desire to participate in their own academic planning and assessment. This accommodation could be invaluable to students who are employed in a particular field and bring with them job related experiences that will advance their learning experiences. The curriculum studied by such students should be specific to their immediate and future needs. Postmodernists support students' participation in the planning and assessment of their academia. They propose a curriculum where students can construct their own knowledge. The contents of the curriculum should be the consensus of the student, the teacher and/or the scientists. In this way, the curriculum will have equal worth (DeLashmutt & Braund, 2001).

Adult learning theorists further propose that adults past experiences play a major role in their learning or education. Andragogy, an adult learning theory states that adults learn from a number of accumulated life experiences and knowledge (Merriam, 2003). This statement implies therefore, that an adult learner as one would expect to see in an American diverse postsecondary environment did not enter the learning environment as a blank slate. This type of learning called experiential learning is well supported by adult education theorists (Brookfield, 1995; Knowles, 1968; Merriam, 2003). Tennant and Pogson (1995) contend that our present and ever-growing numbers of nontraditional student population in postsecondary education institutions will not benefit from formal education strategies. The experiences of these students make them prime candidates for experimental approaches to learning. Adulthood is accompanied by a way of learning which is unique in comparison to the way children through adolescence learn. Adults have the ability to consider and argue opposing viewpoints and to monitor their thoughts and change it, if necessary. Through interactions with day-to-day experiences, adults learn that they must create a balance between what is objective and what is subjective. (Brookfield, 1995). From these findings, it is clear that adults require a curriculum that is different from that studied in their precollege years – one that allows them to use their prior experiences in their college education.

While nontraditional students may not require similar academic and motivational support as their traditional peers, academic and motivational support, are important for their persistence and success. Two groups of students enter college science education program. The first group of students goes on to earn science degrees, while the second group who has the intention and the ability to pursue science degrees switched to non-science degrees (Felder, 1993). The number of students from the second group could be re-educated to prevent the extreme lack of scientists and engineers in the American workforce.

A number of students entering postsecondary education need remedial classes before they can complete their introductory courses (ACT, 2007). Depending on the students' precollege science education, nontraditional students may require the necessary remedial work. Additionally, nontraditional students must be exposed to a number of learning strategies that stimulate their interests in science and mathematics courses (Felder, 1993). Nontraditional students have specific goals. They do not attend college to socialize, but instead they commit to their program of study and focus on their future career perspectives (Bean, & Metzner 1987). Nontraditional students could be very instrumental in helping to solve not only the gender and diversity gap in college and the workforce STEM fields and careers, but in strengthening the STEM pipeline in and across the United States by increasing diversity. Therefore, any method necessary should be used to attract and retain these students in STEM courses at the postsecondary or higher education levels.

Effective Teaching Strategies for Adult STEM Education Success

A high percentage of undergraduate students in America's postsecondary institutions are of age 25 and older (National Center for Education Statistics [NCES] 2004, 2006, 2008). The total number of all undergraduate students exceeded 14.9 million in fall of 2005. Of this number, 4.7 million students were age 25 and over (NCES, 2007, Table 178). This significant number of enrollees makes up a diverse population of students seeking career preparation and advancement, personal goals, enlightenment, and degree attainment. Also enrolled in undergraduate studies and similar courses are traditional and younger students with or without similar interests. This puts pressure on the higher education institutions to develop curriculum and use teaching strategies that will benefit all students.

Adult learners usually have specific reasons for enrolling or re-enrolling in college. Hence, they set specific goals for themselves, and when conditions at the college or university are favorable, these learners usually persist to degree or certificate attainment. Many bring their life experiences and skills, like job experiences, parenting skills, and everyday survival skills to the classroom. Inadvertently, many of them are looking for ways to share their experiences, skills and knowledge, while seeking to learn and develop new ones. This section of the research discusses three teaching strategies that have proven to increase the understandings of postsecondary STEM students.

1. Experiential learning invites the learner to challenge the group with his/or her interpretations, values, beliefs, and meanings about his/or her experience. Experiential learning, rooted in the writings of Dewey (Tennant & Pogson, 1995), is referred to as instructional model of adult education, an instructional method, and an instructional strategy (Council for Adult and Experiential Learning (CAEL), 2002; Hickcox, 2002; Saskatchewan Education, 2000). Much credit is given to Kolb whose work demonstrated that people learned from various methods (Hickcox, 2002).

Simply put, experiential learning is the process of putting oneself into practice. According to the (CAEL, 2002), multiple approaches to instruction such as experiential and problem-based methods used to connect the curricular concepts learned by adult learners to useful and needed knowledge and skills, have been used by instructors in colleges and universities that are monitored by CAEL (2002, p. 10). Experiential learning continues to be an effective pedagogical approach in colleges and universities. Tennant and Pogson (2005), posit that while educators and others usually view good or competent performance as putting theory into practice, such method simply implies that a particular theoretical model can help one understand a particular order of reality (p. 155). That is, the theory when learned is used to complete a particular task, like to know how the car engine works. That understanding however, does not adequately help anyone to perform effectively in the real world. That knowledge has to be transformed into an experience. When the learner is able to use the knowledge to make a failing car engine work then that knowledge becomes reality. Hence, one could say that something does not become real until it is experienced. In experiential learning, the end objective or goal of the educator is to have learners actively involved in the learning process by gaining experience.

Experiential learning involves the necessary phases which are summarized in the following paragraph:

a) Experiential learning is a learner centered, activity driven and induction form of teaching and learning that causes the learner to reflect on an experience and make plans that apply to his or her learning context. In this approach, the instructor involves the learner in an activity and the learner through that activity is able to create or do something that will benefit society. b) The learner must share his or her reactions and observations. In the case of storytelling for example, after the learner listens to a story been told, and has connected the context to his or her learning experience, the learner can share or tell a story from his or her experience. c) The learner must analyze the experience. In doing so, he or she looks for patterns or dynamics between the new experience and the previous experience. d) Principles are derived through generalization or inference. In other words, through inductive reasoning, learners form principles based on reasoning or thinking. At this point, learners can develop question, evaluate their questions, and make generalizations whether to keep, add to, or abandon certain questions, reasoning and/or thoughts. e) Learners make plans to use what they have learned in new situations. Learners can now decide on their plan of action (Saskatchewan Education, (2000). That is, what will they do with their newly found experiences?

Experiential learning is an excellent strategy for developing or enhancing critical thinking skills among undergraduate STEM students. It promotes teamwork, a skill that is required by many STEM employers (Conner, 2004). Additionally, experiential learning can be practiced in and out of the classroom, and the instructor who uses this teaching strategy can make use of various teaching resources.

2. Another effective instructional strategy that has proven to increase students' understandings specifically in STEM education is Peer-Led Team Learning [PLTL] (Crocolice & Deming, 2001). PLTL is a cooperative learning model where teams have leaders. In this model, students are organized into teams or workshop groups. Without teacher intervention, the teams meet on a regular basis, solve problems, and reinforce content. The team leader must have recently completed the course, have demonstrated a higher than average mastery of the course material, and have strong leadership and interpersonal qualities and/or skills. All conditions for the six critical components of the PLTL model must be met before it can be implemented (Cracolice & Deming, 2001, p. 20). The conditions would be listed in the facilitators guide. The ninety to one hundred twenty minutes' workshops are held during class or laboratory time once or twice every two weeks. The group, whose members remain homogeneous for the entire school year,

is small, consisting of five to seven members including the team leader. The teacher provides the material with which the students work, the team leader is the facilitator, and the students discuss and interact with one another.

The sessions start with the peer leader who asks a student to read aloud the first question in the material that is provided. Students then work together towards finding a solution to the problem. The peer facilitator records the steps taken, the sequence in which they were taken, summarizes the students' ideas, and draws diagrams or illustrations based on the students' suggestions. The peer leader provides prompts and suggestions for the application of students' thinking, which help to stimulate students' thought.

The PLTL approach or model has been in existence in colleges and universities for over five years and has being used so far in about thirty postsecondary institutions and one high school in the nation. It came into existence as "one of the five initiatives sponsored by the National Science Foundation (NSF) for system reform in chemistry" (Cracolice & Deming, 2001, p. 22). Based on the research, students involved in PLTL have shown increased critical thinking skills in mathematics, chemistry and other sciences (Cracolice & Deming, 2001; Quitadamo, Brahler, & Crouch, 2009).

3. Collaborative learning, another methodology that can stimulate and bring gains in college students' critical thinking and learning, is a widely researched approach to learning that is presented by the National Institute for Science Education [NISE], (2007) as an educational approach to teaching and learning where groups of learners work together to solve problems, complete tasks, and/or build products. Collaborative learning is grounded in two theoretical considerations. The first is that of John Dewey's

progressivism, which suggests that classrooms should be laboratories where students learn democratic values and behaviors, and as such the schools should "mirror the values of society" (Arends & Castle, 2003, p.1185). The second is in the constructivists' theory, which states that as students work actively to solve problems and discover their own solutions, cognitive learning takes place (Arends & Castle, 2003).

Some of the principles fueling this approach are

a) learning is a natural social act where participants learn by talking among themselves;
b) when students of different levels of achievement work together on an equal status the achievement for each student is higher;
c) deeper interethnic understandings and solidarity is fostered when diverse groups of students work together to solve common problems (Arends & Castle, 2003; Nieto, 1997; NISE, 2007).

In addition to the above collaborative learning values, Nieto (1997) posits that even if the collaborative learning method is used uncritically as it is sometimes used, its benefits among students with diverse populations are well documented. Hence, students in a multicultural environment will always gain if the collaborative approach to instruction is used in the teaching and learning pedagogy. Based on research, the main goals of collaborative learning are: academic achievement, respecting and/or valuing diversity by working interdependently, and the development of social skills through corporative work (Arends & Castle, 2003; NISE, 2007).

Educators or instructors can take several approaches to collaborative learning. Hence, the following discussions of the approaches are not exhaustible. One approach involves the instructor dividing an assignment or topic into four parts. Students form learning teams and all members of the team volunteer to be experts on the topic or assignment. That eliminates the instructor from the expertise position. One quarter of the topic is then assigned to each team and each team works to find the solution to their fourth, or part of the assignment or topic. The team members also work towards finding the best method of helping the other team members understand and learn the material. At the end, all four teams meet together where each team teaches the other teams or groups (NISE, 2007).

In another approach, the instructor presents the goals of the lesson, motivate the students, and connect the new lesson to lessons learnt before. He or she continues to explain the timelines, procedures, student roles, rewards, and group's social skills. The instructor then helps students to acquire the content that is the focus of the lesson. However, the instructor at this time acts as the facilitator and not as the expert. He or she now explains how the teams are to be structured, and helps in transitioning students to their teams. The students work cooperatively in their teams, with the instructor assisting them and at the same time expounding the students' dependence on one another. In the next phase of this approach, the instructor assesses the students or teams' academic as well as cooperative achievement. The learning activity culminates with various types of awards such as letters, bulletin board announcement, and special achievement presentations to the students.

Critical thinking skills are necessary for students in STEM classes. It is determined that the number of adult learners who are enrolling in colleges and universities lack skills that enable them to think critical. It is projected that due to the

American aging population, nontraditional student enrollment will continue to increase faster than that of traditional students. Nontraditional adult learning theories state that adult have learning needs and styles that are different from those of traditional students. This being so, college instructors are pressed with the tasks of finding research based instructional strategies that will help their students acquire the skills, such as critical thinking skills, needed for their persistence and success. Experiential learning, PLTL, and collaborative learning are three research-based instructional strategies which will motivate students to learn, help them develop the critical thinking, social, ethical, and other skills necessary for success, and therefore help them persist to degree attainment.

Conclusion

A literature base exists, describing theoretical models that explain the persistence of underrepresented minorities through the STEM pipeline. However, these models focused primarily on factors of retention, attrition, socioeconomic and demographics, but not on the effects of high school and postsecondary curriculum, curriculum reform, and instructional strategies on underrepresented minorities' undergraduate STEM persistence and degree attainment. Further, the models are usually based on patterns of traditional students within single institutions rather than on underrepresented minorities moving through the entire postsecondary STEM education pipeline (Adelman, 2003, 2006; Horn, 1996; Pascarella and Terenzini, 1991).

There is a consensus regarding the low persistence rate among STEM students in general, with a few researchers alluding to the fact that the persistence rate for African American, Hispanic, and Native American students is dismally low. Educators, business and industry personnel, and the general American public, document the need for a higher percentage of underrepresented minority enrollees and degree completion in STEM fields. However, based on literature, some precollege STEM students are not getting the knowledge, skills, and content, needed to help them persist in undergraduate STEM courses, and the reason is not explained in the literature (Anderson, 2003; Owens, 2009).

This synthesis of literature about the persistence of underrepresented minorities in STEM programs is set in the context of curriculum reform, diversity in STEM education and workforce, nontraditional learners in STEM majors, and research based instructional strategies for STEM education. Based on the literature reviewed, it is apparent that the STEM pipeline can be strengthened if teachers, instructors, and course and curriculum developers consider the needs and differences of the American diverse student body and reconstruct their curriculum in a way that will appeal to the learners. The nontraditional students enrolled in the U.S. postsecondary institutions include a high percentage of underrepresented minorities, who, if motivated and given support will persist through to degree attainment in a chosen STEM field.

CHAPTER 3. METHODOLOGY

Purpose of the Study

The purpose of this explorative qualitative study was to discover why some underrepresented minority college students are successful in their undergraduate STEM programs. In particular, the study examined and compared the precollege or high school STEM curriculum with that used in the participants' university, by soliciting the opinions of students about the preparedness of STEM undergraduate students. It is contended here that the curriculum standards that some students study prior to their entrance into undergraduate STEM programs do not adequately prepare them for persistence, success, and degree attainment in college STEM courses. Hence, in order that postsecondary institution achieve their intended purpose of student persistence and degree attainment, the curricula may have to be reformed, and teaching strategies changed and/or upgraded.

Although postsecondary STEM instructors indicate that knowledge and process skills such as accurately interpreting data and designing an experiment are more important than content acquisition for students' success, high school teachers reported that learning the content is more important for college preparation and success (ACT, 2007). Further, the National Assessment of Educational Progress (NAEP), the national representative for the assessment of math and science, found that secondary students are not at the proficiency level in math and science. At the proficiency level, the students are merely demonstrating solid academic performance in the subjects' knowledge and skills at their grade levels (Kuenzi, 2008). These findings motivated this study, since it is hoped that this study will activate interest and further research in the precollege and undergraduate curricula, as well as the instructional methods used in the education of underrepresented minorities in STEM programs.

The Participants

The participants in this study were science, technology, engineering, and mathematics (STEM) majors who were currently enrolled in a STEM course or STEM courses, in an undergraduate STEM program. Additionally, student participants must have graduated from high school or have obtained the General Education Development (GED) certificate, and self-identify as been successful in their STEM program. Ten student participants completed the semi-structured face-to-face interview.

The participants were of varying age and backgrounds, although predominantly underrepresented minorities. The college was selected because of its location, the make-up of the student body and the number of STEM majors that are offered. The STEM curriculum offers courses and majors in biology, chemistry, mathematics, technology, and research, and enrolls both traditional and nontraditional students. The researcher obtained permission to visit STEM classes and invite students to complete the interview process (Appendix C).

The information collected through the research instrument is confidential. The names, addresses, and other participant identifiers that could identify the participants were not included in the study. All participants were given this information before the start of the interview session and during the selection process. Confidentiality and voluntary participation of participants were stressed.

Research Procedure

In order to get participants' perspectives of how their precollege curriculum affects, or is affecting their STEM persistence and success, a semi-structured individual interview protocol was employed. Persistent and successful STEM participants elicited information about their precollege and undergraduate STEM experiences. A qualitative research design approach was used for this exploratory study. "Qualitative researchers are interested in the meanings that people have constructed, that is, how they make sense of their world and the experiences they have in the world" (Merriam, 1998, p. 6).

Visits to STEM classes at the institution allowed the researcher to verbally invite students to be part of the interview process. The researcher invited and obtained consent from ten learners who felt that they have been successful in STEM coursework and were identified as successful learners by the coordinating or liaison professor at the institution. The learners were advised that their participation is encouraged, but they were not mandated to participate. Additionally, participants were asked to read the content information before completing the interview (see Appendix A). A follow-up visit was arranged to solicit other participants, since two participants who initially consented to be interviewed, dropped out of the study.

The interview was conducted on the college campus at a time convenient to the participants. The interview consisted of sixteen questions relating directly to the students' high school and college curriculum, the effects of the teaching strategies used in high school and college instruction, and the effects or impact of teachers and faculty support on STEM students' success. The last question in the interview protocol—question sixteen—was added to allow the participants to add any pertinent information that they might have omitted, or had forgotten previously (see Appendix B).

To assure an in-depth discussion of the participants' experiences, every attempt was made to ask the questions as written. Hence, some probing was necessary to gather additional information from the participants. When additional questions were needed for the interview, the questions were adjusted accordingly. The scheduled interviews lasted for forty five to sixty minutes. The interview questions were given to the interviewees about twenty minutes before the start of the interview to help them gather their thoughts and perceptions of their experiences. Keeping in line with ethical principles, the answers were audio taped, key-word notes taken and compared for accuracy, the tape labeled, and stored safely for analysis. At the end of the research the tapes were erased.

Instrumentation

The research instrument for this study was created specifically for this research. The instrument is a set of questions for a semi-structured interview relating directly to the students' high school and college curriculum and experiences, the effects of teaching strategies used in high school and college instruction, and the effects of teachers and faculty support on their undergraduate STEM success and persistence. The last question in the interview protocol allows the participant to add any pertinent information that they might have omitted, or might have forgotten previously (see Appendix B).

In order to ensure validity of the instrument the interview questions were examined by reviewers from the field to gain content validity (Litwin, 1995). One reviewer holds a PhD. in Educational Leadership, another holds a Doctorate in Education (Ed.D) in Curriculum and Instruction, and the other holds a Master of Science degree in

Science Education. The questions were re-written to ensure the efficacy of the research design.

Interview Protocol

The semi-structured face-to-face individual interviews were conducted according to the interview protocol in Appendix B. The questions were designed to elicit participants' perceptions of the effectiveness of their high school and undergraduate curriculum to their STEM persistence, the teaching pedagogy that are effective, and the effectiveness of teacher and or faculty support. Using open-ended questions, the interviewer asked the participants questions that solicited detailed and honest responses. They were asked to consider the questions in reference to their age, and academic goals at the time of the interview, and prior to their enrollment in college. In order to maintain the anonymity and confidentially of the participants, the interviewees were identified only by the sequence number assigned according to their position in the interview process.

Data Analysis

A qualitative data collection allows one to collect multiple types of information to answer the research questions, and tends to address research problems that require an explanation of which little is known about the problem, and a detailed understanding of a central phenomenon (Creswell, 2008). In order to develop an understanding of the meaning of this phenomenon, the interviews served the purpose of collecting narratives for this study. The following steps were employed in the data collection process:

1. Arranging the information in themes, and looking for similarities in participants' experiences.
2. Transcribing the interviews

3. Writing individual narratives from one-on-one interviews which included short quotes.
4. Review of the narratives for patterns and themes using QSR International's NVivo 8 qualitative data analysis software.

Consistent with an explorative qualitative design, this study incorporated a context-dependent inquiry, and an inductive data analysis. The three research questions that guided this study are:

1. How does the pre-college curriculum influence the persistence or non-persistence of underrepresented minorities in STEM majors?
2. How can curriculum reform motivate underrepresented minority learners to persist to STEM degree attainment?
3. What types of instructional methods aid student persistence in STEM education?

Questions 1 – 7, and question 13 of the semi-structured interview were used to answer research question one. Questions 5 and 11 – 13 solicited answers for question two, while questions 8-10 and question 14, gave understandings to question 3. In addition, questions 15 and 16 were used to clarify and develop the answers to the three research questions. Supporting or conflicting themes that arose from the data were carefully noted.

Ethical Considerations

In accordance with the requirements of the Capella University Institutional Review Board (IRB) procedures, approval was received from the participating university for its students to participate in the study. A copy of the study's purpose and methodology was given to the liaison professor at the university, prior to the participants selection. The interview participants signed the consent form prior to participating in the interview (see Appendix A). The signed forms were safely kept in a locked room and drawer on the research site, by the researcher.

During the informed consent process, the student participants who participated in the interview were given an introduction to the study and its purpose. The participants were given the opportunity to ask questions about the nature and conduct of the study. It was further reiterated that the data would be kept confidential, and no names would be used in the study.

According to Patton (1990), "direct quotations are basic source of raw data in qualitative inquiry, revealing respondents' depth of emotions, the ways they have organized their world, their thoughts about what is happening, their experience, and their basic perceptions" (p. 21). Direct quotations were included in the data collection and analysis process. To maintain consistency, reliability and credibility, probing questions were asked to allow the interviewees to elaborate on, and clarify their responses and provide structure for each interview question. That strategy further permitted the development of themes that were found in the data.

Conclusion

The purpose of this study was to explore why some underrepresented minority college students are successful in STEM majors. To get clear understandings, successful STEM students were interviewed. The findings of this study will help to address the knowledge and research on the persistence and success of underrepresented minorities in STEM majors. Most significantly, it will enhance the understandings on the effect of precollege STEM curriculum on the success and persistence of postsecondary STEM majors. The study employed a semi-structured face-to-face interview protocol to solicit students' perceptions about the alignment of the curricula and its effect on undergraduate STEM students' success.

The need exists for STEM fields workers in the United States (Davis-Butts, 2006). More importantly, employers are seeking to diversify the workplace (Rogers, 2006). Increasing the number of underrepresented minorities who attain STEM degrees at similar rates as their White and Asian American peers will help to ensure that the American STEM workplace is diversified in the twenty-first century. Decisions made by curriculum planners and STEM educators will greatly enhance what and how STEM students learn (National Institute of Science Education, 2003), thus increasing their success and persistence rate.

CHAPTER 4. DATA COLLECTION AND ANALYSIS

The purpose of this explorative qualitative study was to discover why some underrepresented minority college students are successful in their undergraduate STEM programs. In particular, the study examined and compared the pre-college or high school curriculum with that used in the participants' university, by soliciting the opinions of students about the preparedness of undergraduate students in STEM majors. This was done by interviewing undergraduate STEM majors at the Clark Atlanta University in Atlanta, Georgia. The interview session lasted for three weeks. During that time, two students who had previously volunteered for the interview declined to be interviewed. The reason for the decline was neither sought nor given.

Based on the following criteria the participants believed that the interview questions were properly constructed: (a) length of the interview questions, vocabulary used in interview questions, (b) appropriateness of the interview, (c) appropriateness of interview questions, (d) language used in interview questions, (e) the magnitude with which the participants could elaborate on the questions, and (f) the flow of the interview. In this chapter, the presentation will start with an overview of the participants including the participants' demographic characteristics. Additional items in chapter 4 include: (a) participants' profile and responses, (b) recurring categories and themes, and (c) research findings organized by research questions.

Overview of Participants

The participants in this study were ten STEM majors – three males and seven females at CAU who are succeeding in their chosen STEM fields. All participants have completed three or more undergraduate STEM courses and were in their senior, junior, or sophomore year of college. Six seniors (60%), three juniors (30%), and one sophomore (10%), volunteered for the semi-structured interview, which was used for the study. The sample represented a number of disciplines or majors within the STEM fields and each participant was expecting to enroll in graduate school to study for more advanced degrees such as engineering, pharmacology, and medicine, upon graduating with their bachelor's degrees.

Nine participants attended high school in different states or parts of the United States. One participant attended high school in the Caribbean. Their ages ranged from 20 to 25 years old, and only one participant resided on the college campus. All participants had a high school GPA of 2.8 or higher, and an undergraduate GPA of 2.6 or higher, although some participants reported not having completed advance STEM courses in high school. Participants who participated in advanced STEM classes in high school reported that those classes were mainly math courses. One participant completed two advanced chemistry classes in high school (Table 1).

The family income for the participants ranged from $25,000 to $100,000 annually. Four participants (40%) reported having part time jobs, and of those, one (10%)

had a job in the STEM field. The participants' financial support came from parents, scholarships, grants, financial aid, and / or part time jobs.

Table 1. *Number of High School STEM Courses Completed and GPA Attained*

Sequence #	Biology	Chemistry	Integrated Science	Math	Physics	Technology	Other	GPA
001	2	1	0	5	1	0	0	3.8
002	1	2	0	3	1	1	1	3.6
003	1	1	0	8	0	0	0	3.1
004	3	2	1	8	2	0	0	3.8
005	2	2	0	8	2	0	0	3.5
006	1	1	0	4	0	0	0	3.7
007	1	2	0	4	0	0	0	3.1
008	n/a	n/a	3	3	n/a	0	n/a	4.0
009	1	1	0	3	1	0	0	3.2
010	2	1	0	4	1	0	0	2.9

Table 2.

Participants Current Status and GPA

Current Status —	Average GPA
Graduating seniors	3.6
Juniors	2.9
Sophomores	3.1

Participants' Profiles and Responses

This section presents a detailed description of the students' profiles and responses to the interview questions. Excerpts or quotes from the participants' responses are included. The interviews were transcribed so that similarities in responses could be noted.

The interview with participant 001 took place in a conference room of the campus library and lasted for approximately 45 minutes. This female senior, majors in physics, and plans to pursue graduate work in architectural engineering. She completed four science courses and five math courses in high school, with one science course taken during the summer. She stated that the physics courses she took best prepared her for her undergraduate studies. The participant, who transferred from a public high school to a private high school, stated that the curriculum she studied in the private high school was more advanced, hence, "the placement test was not difficult for me, and the math classes in college were not difficult". Because she pursued a very rigorous technology course in middle school, she tested out of technology in high school. She stated that the classes taken in high school very much prepared her for her undergraduate course work. "However" she said, "in high school math and science classes, you are taught to use the calculator. If the college course is not calculator friendly, one will experience some difficulty. You have to know your formulas." She stated that she used the formula learned in her high school physics and algebra classes to solve problems daily. The participant contributed her success to a solid high school STEM background, small college classes, having high school and college instructors that use hands - on approach in their teaching methods, dedication, love for her field of study, and the one-on-one help that some college instructors are willing to offer. When asked how she would rate her high school curriculum as compared with the curriculum used in her college STEM classes, she rated it a ten on the scale of 1-10. She explained: "I rated it a ten because I always assumed that everyone in high school had critical thinking and problem solving skills, but when I came to college I found out that it was not so." (001).

Participant 002 was interviewed in a conference room, of the college library, and the interview lasted for approximately 50 minutes. Included in the high school science courses that she completed was forensic science, which she stated prepared her tremendously for her undergraduate courses. Before completing her state's high school exit examination, this graduating senior attended multiple science couching classes outside of the regular school curriculum, which prepared her to pass the examination. Although she feels that the high school courses somewhat prepared her for success in the college courses, she had to take college algebra in her freshman year to refresh her memory, and spent countless hours relearning some of what was studied in high school, since the material was presented at a greater level of difficulty in college. When asked whether she was using the knowledge and skills learned in her high school math classes here in college, participant 002 replied, “No, because everything had to be retaught to me now that I am in college.” She further stated that in the public high school she attended, everybody was failing science so she had to seek hours of one-on-one help from her science teachers. The individual help helped her succeed in her science classes. She noted that her high school science teachers used a lot of visuals in their teaching methods. That helped her since she is a visual learner. The participant further noted that her high school math teachers used a lot of storytelling in their teaching methods. “That was good in high school,” she explained, “but once in college, storytelling was over.” In spite of the many math courses taken, she felt that she was not prepared for her college math courses. She contributes her success to the teachers and instructors who are passionate about helping their students, her hard work and dedication to her studies, the small classes at the university, the learning experiences gained from work in the research laboratory, and the personalize instruction— like recitation—she receives at the college. Recitation is a tutorial type instruction offered to CAU’s students, where students can gain better understandings in areas where they are having difficulty.

The interview with participant 003, a male college junior majoring in chemistry/civil engineering, lasted for approximately 45 minutes. Another conference room of the library was the site of the interview. The participant took two science classes—biology and chemistry—in high school, and stated that both courses prepared him for his undergraduate courses. He completed eight math courses in high school, explaining that he was an advanced math student in high school. When asked, “In what ways did the math courses you took in high school prepare you for success in your undergraduate math classes here (at CAU)?” The participant said that different topics like ordering concepts, vectors, and graphing ideas that he learned in high school, helped him to understand and complete the concepts which are taught on a more difficult level here. He praised his high school math and science teachers for giving him a solid background and for making the STEM classes which he completed, applicable for life. In comparing the teaching strategies used in college with those used in high school, he explained that in college the instructors teach you how to teach yourself. “They teach the book, you have to find the best way to learn,” he stated. Although he thought that he completed a good STEM curriculum in high school, he gave it a 6.5 (out of 10) comparison rating, arguing that after his interaction with other students he found out that some of those students pursued a more advanced STEM curriculum. This participant contributed his success and persistence to his high school STEM foundation, self-motivation, prioritizing, consistent hard work, and the earning potential and future job prospects of STEM majors.

The interview with participant 004, a graduating senior and chemistry major lasted for 45 minutes. She completed eight science courses and eight math courses in high school. When asked whether the courses that she completed prepared her for success in her college courses, she said that some did while others did not. “I had difficulty with calculus here” she stated, “pre - calculus did not prepare me to take calculus. I could not move from one step to another. However, I had a great foundation to build on in other of my courses." She continued to explain that, with the speed in which the courses are taught at CAU, one needs to have a very good background in all the courses in order to be successful. "The lessons are much more in-depth here, and as I said before the professors go very fast. They assume that you can follow." (004).

When asked whether the professors follow the same step-by-step methods used in high school, the participant said that it was used to some extent. "However," she said, "the professors here motivate you to be independent learners." As stated by her, the work done in high school did help to develop her critical thinking and problem solving skills. She explained that the teaching methods used in college helped her to become a more independent learner, to communicate more clearly, and enhanced her research skills. "Since the professors move exceedingly fast paced, and you do not get much instructor attention, you have to learn how to get the help you need and also how to learn the material on your own", she added. This participant attributes a positive mind set, good study habits, seeking help from professors and other students in areas of difficulty, caring professors, and the recitation as factors that contribute to her success in the STEM field.

Participant 005 interviewed for 40 minutes in a conference room of the university's library. This male chemistry major is a graduating senior who stated that he took six science and eight math courses in high school. He further stated that all the courses that he took prepared him for his college courses. He took extra classes outside of the normal school hours, which better prepared him for undergraduate work. Some of the high school teaching strategies that his high school STEM teachers used were hands-on or inquiry-based, test taking skills practice, and field trips where they would have preplanned activities for students to complete. “Another excellent thing I did in high school was to participate in science projects where I had to plan and develop projects worthy of competing against other students from other schools.” He continued to explain the benefits of group activities, laboratory (lab) activities, and the professors’ way of teaching them how to teach themselves. This participant noted that he believes all the learning experiences will be helpful to him on his job, but that he would lean towards the research and lab activities he completed as the courses that prepared him most for the workforce. He gave his high school curriculum an eight (on a scale from 1-10), as compared to his college curriculum, and attributes his persistence and success to his ability to stay motivated, to ask questions, and to stay in constant dialogue with his professors. From his job he has gained experiences that will be further contribute positively to his career after obtaining his degree.

The 50 minutes interview with graduating senior 006, took place in the college library conference room. This participant stated that she took only two science courses— biology and physic— in high school. “None of these courses prepared me for college science”’ she stated. She completed four math courses in high school and those she said gave her strategies and techniques on how to approach and solve problems. She completed two technology courses, which were not directly related to STEM. She acquired the background information from the high school math courses that she completed, but did not get that from the science courses taken. Although she is a chemistry major, she had not taken a chemistry course in high school. “The math courses presented the background information for pursuing chemistry and college math, however, I needed to take a chemistry course in high school." (006) She further explained that she did not take chemistry because it was not offered at her high school. Participant 006 complained that she did no hands-on work or labs, neither was there group or peer activities. When asked how the teaching strategies used by college professors have helped or not helped in her persistence and success, she said:

> "Some teachers do not have good teaching strategies. Some do not take the time to go through the problems step-by-step. There are lots of labs here. Although it is very fast paced information, you can follow the step-by-step labs and work. Also, the recitation helps because you can go in and get more one-on-one attention where you can ask questions and get help." (006)

She rated her high school curriculum a five out of ten when compared with her college STEM curriculum. The reasons given were that the high school did not offer a variety of science courses, and the science curriculum did not involve the use of labs and hands-on learning activities. Skills like learning the computer, using research tools, and learning research techniques that are part of her job experience helped her in her daily course routine. The factors that contribute to her persistence and success are connections with her professors, self-motivation and hard work, the science research which is part of her job description, and the job prospective and salary she expects after graduation.

The interview with participant 007, a junior and chemistry major, lasted for 45 minutes in conference room of the library. He reported taking three science courses in high school, two of which were honors chemistry. He stated that none of these courses prepared him for his college STEM career. In comparison, he took four math courses which did prepare him. When asked how did the courses prepare or not prepare him, he stated:

> "I was in advanced math classes. I did the work in high school, so for the first few semesters, the work that I was doing here, I had already completed in high school. For science it was not the same. I did not have a clue. Although I was in advanced chemistry, I did not learn any of the material that was taught here."(007)

This participant was originally a psychology major who switched to chemistry – a STEM major, mainly because of his father's influence. "My father said he would not pay school fees for me if I did not major in a STEM field," he said. He complained that he deterred from math and science majors because of his STEM experiences in high school. The instructional methods used in high school did not help him because he was always told what happened but not how and why it happened. He did not understand the relevance of each course, or how it pertains to everyday life. "Teachers told you everything, and if you did not do it, the teachers did it for you," he said. This participant thought that the instructional strategies used in his college classes helped, depending on the type of class and the instructor. He is using the knowledge and skills gained in his high school math classes in his learning experiences now, and he believes that he will use his undergraduate learning experiences in his future career. He rated his high school science curriculum seven out of ten, stating that it was a good curriculum which was poorly presented. His math curriculum received a nine out of ten. Participant 007 contributed his persistence and success in a STEM field to his father's threats, job and financial prospects, and the amount of time and money that is already spent on his education.

Participant 008, a graduating senior, was interviewed in a conference room of the college library. The interview lasted for 45 minutes. She completed a total of three integrated science courses, and three math courses in high school, and although she completed a different curriculum than that of the United States, she did complete all the requirements for her high school diploma. She happily reported that all the courses prepared her for her college career. "I am happy to say that I was so prepared that my freshman and sophomore years were a breeze", she said.

When asked how the work had prepared her for the undergraduate courses, she said that all the math and science concepts and skills that she was presented with during her first and second years of college, she had already seen and/or completed in high school although the high school courses were not as in-depth. She also received a high score on her college entrance examination. She completed a rigorous computer programming class in junior high school, but opted out of it in high school. This participant contributed her high school success to great teachers, a good curriculum, and hard work that brought continued success. The high school teaching strategies that she rated highest were the practical hands-on activities that showed the application of the concepts learned. The college instructional strategies that she rated the highest were those that had labs that corresponded with the concept or theory being taught, and the recitation where students can get one-on-one help in problem solving. She argued that in high school she did many writing in science that increased and/or sharpened her critical thinking skills and helped tremendously in organization, time management and note - taking skills necessary for college success. The learning experiences that she will take to her future job or career include research with experimentation, time management and organizational skills. This participant rated her high school curriculum a ten, as compared with the college curriculum, stating that the curriculum covered what she learned during the first year of college, although the college curriculum is more detailed in its approach. She attributed her undergraduate success to her passion for the STEM fields, her strong precollege STEM background, high school teachers and college professors who are passionate for the program and are willing to help their students, hard work, and time management skills.

The interview with participant 009, a chemistry major and college sophomore, lasted for 50 minutes in the college library conference room. This very outgoing interviewee reported completing three science courses and three math courses in high school. She added that her classes were at the general education level – that is, none of the courses was taken at the advanced level. She said that all of the STEM classes taken in high school prepared her for her undergraduate work. However, some prepared her better than others. They all gave her a general knowledge into the more in-depth courses that she has taken in college. "By learning for example, the chemical and math formula in high school, I am able to apply it to at least some of my work here," she continued.

The instructional strategy used in high school that she considers the best are those that help her to think. When asked to give examples she said those that taught her to plan experiments, and solve problems associated with vectors. She explained that although she did not obtain all the problem solving skills she now needed, she certainly have a lot to build on. She did not think that she was given enough critical thinking skills practice in high school. She was unsure about the learning experiences that she would take into her career or job, but was certain that some of what she learns in college will be used in her future career as a pharmacologist. The factors that contributed to her success were her excellent high school STEM background, caring instructors both in high school and college, her love for the sciences, and a determination to succeed, coupled with hard work. Participant 009 gave her high school curriculum a 8.5 out of 10 when compared to the college curriculum. The reason for her rating was that others of her peers had a greater curriculum and were therefore ahead of her in certain areas of her academics.

The 50 minutes interview with participant 010 took place in a conference room of the university's library. A junior and biology major, with the expectations of entering medical school after graduation, this participant seemed happy and ready to talk. She reported completing four science and four math classes in high school. She took accelerated science and math classes. All her courses and instructional methods used in high school prepared her for her college career success. However, her favorite classes were anatomy and geometry. She learned how concepts and theories apply to everyday life. She explained that one must be able to do applications when in college. She argued that the teaching strategies of her college instructors work, depending on the course taken or the problem to be solved. She continued:

"A big difference here is that the instructors go very fast and sometimes do not seem to care whether you get it. If you do not have a good background in the topic, you can sometimes miss it. I think if they see that the majority of the students get it, then they just move on to the next problem. That is why recitation is so important, because in there the instructors move slower and you have more time to ask questions and get one-on-one help." (010)

She explained that the lab work in college provided the hands-on that is necessary for grasping the concept and making the theory applicable. She said that her high school curriculum provided the opportunity for students to develop problem solving and critical thinking skills. She noted however, that sometimes the teachers do not give them enough practice in those areas. Participant 010 rated her high school curriculum a 9.0 out of 10.0 as compared to the undergraduate college curriculum. She gave it that rating because it contained most of the "stuff" that she did and is doing at college, especially during her freshman year. She attributes her persistence and success in the STEM fields to dedication and hard work, motivation from her parents, a strong high school STEM background, and the help received from her college instructors especially in recitation.

Data Analysis

Thematic Categories Found

The transcribed interviews were coded and analyzed, for patterns and themes using NVivo 8. Participants' concepts and beliefs formulated substantive patterns and/or categories (Maxwell, 2005). The data analysis from the ten participants in the study revealed five relevant categories and themes.

1. Success factors for underrepresented minority STEM students
2. Perceived factors influencing continued success and persistence in STEM
3. Instructional strategies that can influence STEM students persistence and success
4. Perceived ways by which instructors can aid STEM students persistence and success
5. Advice for underrepresented minorities considering majoring in a STEM discipline

Based on the above thematic categories, five themes emerged from the data that reflect the opinions and perceptions of the participants.

1. Having a good high school STEM background, a love for the STEM field, hard work and dedication are the most important success factors for minority STEM students.
2. Self - determination and time management are the most influential factors for continued STEM success.

3. Hands-on activities, whether in the lab or in the classroom, scheduled tutorials, and group work, are instructional methods that contribute to minority STEM students' success.

4. Continued support, one-on-one help, and more stringent and demanding coursework or curriculum, are factors that can motivate minority STEM students' persistence and success.

5. To be successful in the STEM fields, students must be passionate about the field of study, must prioritize, must seek mentors and peers with similar values, and must keep a constant dialogue with their instructors.

In this section, the findings will be discussed as they relate to the three research questions. Again, excerpts from participants' responses will be included.

Research Questions

The three research questions that guide this study are:

1. How does the pre-college curriculum influence the persistence or non-persistence of underrepresented minorities in STEM majors?
2. How can curriculum reform motivate underrepresented minority learners to persist to STEM degree attainment?
3. What types of instructional methods aid student persistence in STEM education?

Question 1

Responses from questions 1-7 and question 13 of the semi-structured interview were used to answer research question 1. The majority of the participants' responses indicated that the precollege curriculum influenced their STEM persistence and success. Those participants who completed three or more science and math courses in high school indicated that their first year of college was not difficult. The courses taken during their first and even the second year of college were somewhat similar to those taken in high school. "The material covered in physics at college was like a refresher – formula and all" (001). I attended multiple science classes which prepared me for the Texas exit exam and ultimately for my college courses" (002), and "How did the courses prepare me? I developed critical thinking and logical skills that helped me to solve problems." (005) Other participants said that they were using the knowledge and skills acquired in high school to complete their college science courses but not in their math courses "Now that my science courses are more in-depth, I am glad I had the background in science. For math, as I said before, is a different matter, I had to take remedial math." (004). For this participant the high school science curriculum exceeded the math curriculum in terms of preparing her for undergraduate work. Participant 003 said, "Yes, a lot of stuff we learn in our first year, we learned them in high school although they were far more in-depth. So, high school background prepares you for more in-depth learning."

Most participants stated that they did not complete any substantial technology courses in high school. Those who reported completing a technology course agreed that the course completed was not related to, or directly helpful to them in the STEM field. "The technology courses that I took—like basic word processing and typing— help me in that they help me type my papers and so on." (010). Two participants said that the technology courses they completed in high were useful to them in their STEM coursework.

Question 2

Interview questions 5 and 11 – 13 were used to elicit responses to question 2. It was discovered from the interview protocol that learning experiences from high school and college as well as the curriculum are helpful to STEM students' success. The learning experiences from high school that were reported to be most useful to the participants were: (a) labs - where students experimented on what they had learned theoretically (b) field experiences - where students participated in outdoor or field activities (c) one-on-one instruction - where teachers explained the material step-by-step to one student at a time, and (d) field trips - where students had pre-planned assignments to explain how the theory was related to the practical. One participant stated,

> "Research with experimentation helped me a lot. Teachers did not just tell you, they showed the practical side of the theory and provided opportunities for labs or hand-on activities. You could see how it applied to everyday life. You got the opportunity to see how things are used in everyday life in order to appreciate it." (008)

Other participants reported experiences like learning proper time management skills, organization skills, independence or learning to learn on your own, learning good study habits, and learning how to study in groups as other high school learning experiences that are helpful in college.

Majority of the participants thought that some learning experiences from their college STEM education will be useful in their job or career. The experiences that were mentioned most are those gained from using research tools and techniques, learning to communicate research findings, processes that are used in extracting and isolating products, data collection and analysis, and how to personalize projects. Most participants argued that the undergraduate STEM curriculum when completed, will prepare them for the STEM workplace. Participant 007, a graduating senior stated that whether he finds a job or make one, what he has learned in college will be useful to him. He stated,

> "It is told to us every day here at CAU to find a way or make a way. Use whatever is available to pave the way. Therefore I have to use whatever I learn in college whether I get a job or not." (007)

Another participant stated that some of the coursework completed in college will most definitely be useful in her future employment. However, she thought that course work not directly related to STEM could have less emphasis. When asked, "Do you think that your college curriculum when completed will adequately prepare you for the STEM workplace? She replied,

> "Yeah, I think it will prepare me, but I think we have to complete too many courses that are not STEM courses …… Like history, psychology, you know. The research and investigations that is built into the curriculum will certainly be useful to me though." (010)

Question 3

Responses to question 3 were elicited from interview questions 8-10 and 14. The responses from 80 % of the participants revealed that instructional strategies that are inquiry based increased students' participation and therefore enhanced learning in the STEM fields. Those teaching strategies, as stated by those participants are hands-on and student led. Other teaching strategies that were highly rated include group activities, reviewing of the previous lesson before teaching the new, providing time for review and questioning, visual instruction, and relating the lesson to practical life. Two participants (20%) included lecture with the use of technology in their responses. Of that 20%, one participant noted that such lectures "make more sense" when they are followed by a lab. The eight (80%) participants who did not include lecture as one of their favorite strategies, noted that they learn from lectures when they read the chapter(s) prior to the lecture.

The teaching strategies that are rated as excellent in promoting STEM persistence were those also used by high school instructors and favored by the participants. All participants (100%) agreed that the high school lessons were presented at a slower pace than those at the college. One participant—a physics' major—who did not complete a high school physics class, noted that the professors rushed through the lessons which were "foreign" to her. She contended that she had to seek one-on-one help outside of class time, in order to understand the material. This participant, as well as the other nine, echoed high praises for the help they received from recitation. All participants suggested that the faculty support that has proven to be the most helpful to them is the out of class tutorial that are scheduled by most instructors. According to participant 009,

> "When I meet with the instructor out of class time, I can get things squared away. I can ask questions pertaining to the lesson or anything that is bothering me. It is important to develop a good rapport with your instructors." (009)

Another faculty support that was reported as invaluable is the senior or graduate student mentoring, organized by some professors. One participant explained that his mentor was his hero, and that he might not have had a student mentor if it were not for one of his STEM instructors.

Conclusion

Responses elicited from the study participants were similar. Eight of ten (80%) participants agreed that their high school curriculum contributed to their STEM persistence and success. However, different levels of rating were given to the high school curriculum as compared to the college curriculum. According to the responses elicited for research question 2, it was discovered that learning experiences from high school are helpful to their undergraduate STEM persistence. Some participants argued that the experiences gained in high school contributed both positively and negatively to their undergraduate STEM experiences. However, majority of the participants contended that the experiences gained from their high school STEM classes have contributed positively to their undergraduate STEM success, and will contribute positively to their STEM career. Those participants further argued that their undergraduate STEM program, when completed, will prepare them for the STEM workplace.

Research question 3, sought responses from interview questions 8-10 and 14. Various instructional strategies were reported to be positive contributors to the participants' STEM persistence and success. Some participants noted that the teaching strategies that were also used by their high school instructors were most helpful to their persistence and success. Overall, instructional strategies that were student focused and included hands-on activities were rated by the participants as being the best contributors to their success. Responses from the participants revealed that other factors than the high school curriculum, contributed to their undergraduate STEM persistence and success.

CHAPTER 5. RESULTS, CONCLUSIONS, AND RECOMMENDATIONS

The purpose of this study was to explore the persistence and success of underrepresented minorities in undergraduate science, technology, engineering, and mathematics (STEM) majors. Specifically, the effect of the precollege STEM curriculum on the preparation and persistence of undergraduate STEM students was examined. An exploratory, qualitative approach was identified as the appropriate methodology to address the research questions, and the data collecting tool, consisting of semi-structured interviews was used to give rich descriptions into the STEM students' preparation, persistence, and success. This chapter provides a summary of the results, conclusions, and recommendations.

Summary

STEM success is very important both at the college and national levels. Many jobs in the STEM fields are given to non-Americans because of a lack of qualified STEM employers. The crisis becomes even greater for employers who are seeking to diversify their workplace, because of the small percentage of underrepresented minorities holding STEM degrees (American Council on Education, 2009; Anderson & Kim, 2006). Further, global competition in science and engineering talent has intensified, and it would be to

America's advantage to enroll a higher percentage of its students in STEM programs, (Council on Competitiveness, 2004), and encourage their persistence and success.

Three research questions were posed in this exploratory qualitative research study. Question 1: *How does the pre-college curriculum influence the persistence or non-persistence of underrepresented minorities in STEM major?* This question sought to get a detailed understanding about students' academic preparation before enrolling in college STEM programs. Question 2: *How can curriculum reform motivate underrepresented minority learners to persist to STEM degree attainment?* Question 2 was intended to explore whether a curriculum reform was necessary to attract and maintain underrepresented minority students in college STEM programs. Question 3: *What types of instructional methods aid student persistence in STEM education?* This question was intended to investigate and explore best practices and methods of educating STEM majors. Through semi-structured interviews, the opinions and feelings of underrepresented minority participants were achieved.

Five chapters make up the component of the study. Chapter 1, which is the introduction to the study, identified the problem, and stated the study's background, significance, and purpose. Chapter 2 reviewed significant literatures connected to the study, hence, providing the conceptual framework for the study. As literature about the precollege and undergraduate STEM curriculum was reviewed, the benefit and significance of the literature was discussed. Chapter 3 outlined and discussed the methodology used for the collection and analysis of data used in the study. Chapter 4, provided the results of the interview, and noted categories and themes revealed in the data. Chapter 5 provides the presentation of the findings, the limitations of the study, the conclusion, and recommendations of the study.

Limitations of the Study

The study was conducted at a four-year educational institution in Atlanta, Georgia. Although the students were predominantly underrepresented minorities, the participants represent various cities, states, schools, and socio economic backgrounds. It is assumed that the responses of participants were accurate and honest. However, as typical of qualitative studies, there are limitations. According to Creswell (2008) a limitation is the potential weaknesses or problems of design of the study that could potentially reduce the study's validity and scope. Since responses came from predominantly African American students, the data may not have been a reflection of the majority of underrepresented minorities in STEM majors which would include Hispanics, and Native Americans. The findings might be unique to the participants included in the research study.

Patton (1990) argues that there are limitations to how much can be learned from what people say, therefore, to understand the complexities of many situations, direct participation in, and observation of the phenomenon of interest, may be the best research method. Answers to questions needed to be verified to avoid misunderstanding and biases. However, the researcher's personal biases might also limit the accuracy of the study. In order to get detailed understandings of the feelings, and attitudes of the participants' precollege and undergraduate experiences, and yet pose the interview questions as closely to the original as possible, some researcher biases might have been included in the probing. Since direct quotations from participants are included in the study, and the participants were given the opportunity to listen to and make adjustments to their personal recordings, the effects of the interview limitations are minimal.

Summary of Research Findings

Data from this qualitative study revealed several factors that directly influence or affect undergraduate STEM students' persistence and success. The most important success factors that were identified are, having a good high school STEM background, a love for the STEM field, and hard work and dedication on the part of the students. Participants gave meaningful insights into their experiences, perceptions, thoughts and feelings about their success contributors. It was noted earlier that a rigorous precollege curriculum contributes to students' persistence in the STEM fields (Adelman, 2006; Anderson & Kim, 2006). Also noted however, was that students from low socioeconomic backgrounds are less likely to attend high schools where they pursue a rigorous curriculum (Anderson, 2006, p. 13). Findings from this study support both premise. Participants who attended high schools where they pursued and completed rigorous math and science curriculum, found that it was easier for them to "keep up" with their college work and had an easier grasp on the subject matter than those students who did not. They acknowledged that their instructors taught at a faster pace than their high school instructors, but because of their fore-knowledge of the subject or topic, the fast-paced instruction did not pose a problem. Most specifically, they were able to acquire good grades for their work.

Owens (2009) maintains that the current education policy in the United States, which is strongly influenced by the No Child Left Behind Act of 2001, has greatly influenced what is taught in the classroom and how it is taught (p. 49). Participants whose high school STEM curriculum aligned with their undergraduate STEM curriculum were notably persistence and successful. The participants who studied this type of STEM curriculum attributed their persistence and success to having a good precollege STEM background. Hard work and dedication on the part of the participants were highly rated as nuggets for STEM persistence and success.

The first research question sought participants' concepts and feelings on effect of the precollege curriculum, on the persistence and success of postsecondary STEM majors. Although most of the participants agreed that the completion of a rigorous high school curriculum plays a key role in undergraduate STEM students success, those participants further maintained that self determination and proper time management are also very important. They stated that the more rigorous the curriculum, the more dedicated one has to be to complete it successfully. This notion by the participants was verified by the fact that one participant, a successful chemistry major, did not complete a chemistry course in high school. That student did however complete two higher level math courses. The NCES (2009) report contended that students who completed higher-level mathematics courses to include, trigonometry and calculus in high school, were most likely to persist to STEM degree completion.

The curriculum that is developed to address and include multicultural learners, will address the learning needs of all learners. However, as Gutek (2004) so aptly posits, the curriculum contains what knowledge curriculum makers deem worthwhile for society and society's members. Research question 2 sought to discover how the reform of the curriculum could motivate underrepresented minority learners to persist to STEM degree attainment. Although some precollege and undergraduate curriculum emphasizes the quantity of knowledge learned instead of the quality, the participants in this study placed greater importance on the quality of knowledge learned. While instructors are “racing” to complete the number of competences the children should learn, the students are desiring to get the knowledge that will be useful to them in their everyday and professional lives.

Hence, the participants contended that they prefer a curriculum that focuses on inquiry and problem solving, which in turn will enhance teamwork, communication, and leadership skills, but also a strong mastery of the content. The persistent participants praised the areas of study that involved research with experimentation, such as in and outdoor laboratories, and field trips where students had pre-planned assignments to explain how the theory was related to the practical. As one participant stated, “A curriculum that involves inquiry or hands-on work, help me to see how what I am learning applies to everyday life. I get the opportunity to see how things are used in everyday life in order to appreciate them” (008). Owens (2009) in writing about the precollege science curriculum maintains that in order to ensure that students get the time needed “to explore science and acquire essential knowledge and skills” the amount of material that the present science curriculum contains must be extremely reduced (p.53).

The knowledge and skills that were identified by the participants as important for today’s workplace, do require that they are given the time to focus on, explore and learn the big ideas instead of many small details. Participants who were engaged in that type of curriculum were confident that they had the skills necessary for the twenty-first century workplace. Based on the data collected, inquiry-based laboratory curriculum was adopted in both the precollege and undergraduate curriculum of most participants.

Research question 3 sought understandings about the teaching strategies that enhanced STEM persistent and success. Data revealed that the number one strategy mentioned by majority of the participants involved inquiry instruction. Participants prefer instruction that were hands-on, student led, and involve group activities where they can learn from other students' experiences. Literature revealed that Peer-Led Team Learning, where students are group leaders, and experiential learning, where the learner challenges the group with his/her experiences have been proven to increase students' understandings specifically in STEM education (Crocolice & Deming, 2001; CAEL, 2002).

Underrepresented minority students require continuity in their STEM courses. Participants who could relate what they learned in high school to that which was taught during their first year of college contended that the work was not difficult. On the other hand, those participants who did not see the continuity in the curriculum reported that they had to seek extra help and worked very hard to succeed their first year. Those students complained about the fast-paced teaching methods used by their college instructors. Further, all the participants reported that they preferred the classes where the instructors used the teaching methods that were used by their high school instructors.

Other factors that the data revealed as pertinent to the persistent and success of underrepresented minority STEM students, are one-on-one help from instructors and able peers. All the participants praised the recitation—a tutorial offered by the science department of the university—where students get the opportunity twice per week to review lessons with an instructor or graduate student. They bask in the idea that they have the time to ask questions and gain greater understandings about the subject matter.

Unexpected Findings

The data revealed that one student who completed science and math honors classes in high school, enrolled in college as a psychology major. He switched majors after his first year of college. He argued that the STEM classes he completed in high school deterred his interest in pursuing a STEM degree. The participant complained that his high school teachers told the students everything. Hence, while students participated in some hands-on activities, they followed the step-by-step instructions of the teachers and did not get the chance to explore or learn on their own. Further if the students did not know what to do the teachers did the work for them. When asked why he switched to a STEM field, he said that he was forced to switch by his father who is paying the tuition and also by the employment prospective of a STEM major. He complained that he struggles through some of his math and science classes because of his poor high school preparation.

Another student who thinks that it is difficult but not impossible to be successful in undergraduate STEM programs completed only two science courses and two math courses in high school. All of the courses were completed at the general level. Although a chemistry major, she had not taken a chemistry course in high school and reports that her success is due to hard work and dedication to her major, and pursuing one-on-one help from instructors and peers when needed. She maintains that her high school curriculum did prepare her for college persistence and success, and that the college curriculum when completed will adequately prepare her for the workforce.

One theme that was derived from the study was that successful STEM majors must be passionate about their fields of study. The love for the major seems to explain why this participant who completed fewer STEM courses in high school is more successful than the student who completed several high school honors STEM courses with good grades. Another factor that needs consideration is the students' level of skill that was mastered in high school. The completion of several high school STEM courses does not equate to students' success. In addition, based on the data, the acquiring of much knowledge without the skill to apply that knowledge may deter instead of enhance STEM persistence and success.

Conclusion of Findings

Five major themes – (1) having a good high school STEM background, (2) self determination and time management, (3) inquiry method in labs and in the classroom, (4) continued support of instructors and peers, and (5) recommendations for STEM persistency and success, emerged from this investigation.

Having a Good STEM Background

The number one theme being having a good high school STEM background seems to confirm what previous studies had noted. Although those studies did not focus on underrepresented minority students, it appears safe to say that based on the findings of this study, a good high school STEM background plays a major role in the persistence and success of underrepresented minorities. Some of the factors that trigger into having a good high school STEM background are a love for the STEM field, and hard work and dedication. The participants who were most successful showed a love for and were passionate about continuing unto graduation in their chosen field. The participant who did not originally enroll in a STEM field although successful and persistent, did not reveal the enthusiasm as revealed by the others. Indeed, this confirms that having a good high school STEM background does not necessarily equate with the number of STEM courses taken. Further, all the participants reported that they had to work harder than their peers in majors other than STEM, in order to be successful. This means that STEM persistence and success requires hard work and dedication.

Self Determination and Time-Management

Although most participants were academically prepared for undergraduate STEM classes, they find that how determined to succeed they were, and how they managed their time, were major contributors to their success. They learned early in their first semester that they had to "give up" things like weekend partying, and "hanging out" with friends in other majors. They acquired time management skills which helped them maintain healthy study habits. Participants reported that they sought help from peers, instructors, and mentors who helped them plan study schedules. Such determination caused them to develop and maintain positive relationships with people who influenced their lives.

Inquiry Method in Labs and in the Classroom

The inquiry or "hands-on' method of teaching by far outweighs other forms of teaching strategies. All participants favored the inquiry method as the best type of instructional method used by their high school and college instructors. They unanimously agreed that STEM courses require that STEM majors participate in real life activities that will be beneficial to them in the future, instead of being told everything by lecturers and instructors. They spoke proudly about their participation in internship and other forms of research presented to them by their college. Some discussed with enthusiasm the learning experiences they derived from outdoor labs and field trips, when they were simply given abstract questions or problems for which they would provide answers and solutions.

Those were some of the classes that equipped them with critical thinking and problem solving skills.

Continued Support from Instructors and Peers.

The continued support from instructors and peers, featured significantly in the persistence and success of underrepresented minority STEM majors. This type of support is invaluable both at the high school and college levels. Participants spoke of the importance of knowing your instructors and keeping in constant dialogue with them. Instuctors who are willing to spend extra time listening to and helping their students are highly regarded by them. Further, scheduled tutorials with instructors are major benefits to underrepresented minority STEM majors. They gain insights, get new ideas and understandings from those one-on-one sessions that would not be possible in the regular class sessions.

Of equal importance is the peer support. Some participants complained about the reluctance of some of their peers to participant in study groups, noting that the study groups help them to gain deeper understandings into some topics. Also noted was that some students are stronger in certain areas than in others, hence, study groups can be beneficial to all involved. Peer support for others, however, simply means having others to "unload' on. They value their peers' involvement in their personal affairs, and whenever they are overwhelmed. For whatever the reason, instructor and peer support contribute significantly in the participants' persistence and success.

Recommendations for STEM Persistence and Success

To be successful in STEM majors, underrepresented minority students must be passionate about their fields of study. This was the consensus of most participants of this study. Participants noted that one must know at least one thing that motivated them to pursue the field and focus on it. Further, once started, STEM majors have to prioritize. They must be willing to be less involved in the things that would cause them to lose focus. Participants noted that prioritizing involved aligning themselves with peers and mentors with similar values and/or interests, and keeping a constant dialogue with instructors. Participants argued that persistence and success of underrepresented minorities in STEM majors is difficult, but not impossible to attain, but it must in a great part begin before enrolment in college courses.

Recommendations

Practice

Educating a higher percentage of undergraduate enrollers in STEM programs is of major importance in our society for some time now. In spite of the many research done on America's competitiveness in the field of science and technology (ACT National Curriculum Survey 2005-2006, 2007); American Council on Education [ACE], 2009), much work is yet to be done to increase America's science and technological competitiveness with that of other developed and developing countries (NAS, 2011). Academic institutions in the United States can play a major role in decreasing the competitive gap between the United States and its rivals. The role of academic institutions is to prepare students for the future. Underrepresented minority is the fastest growing people group in the United States, yet they are the least represented in the STEM pipeline of the nation's high schools and colleges. The practice of educating this people group in the STEM fields needs to be re-examined by those who are directly involved in the day to day instruction of the students.

Participants interviewed for this project revealed that having a good STEM background does not depend on the amount of facts remotely learned in class, or the number of STEM courses taken at the pre-college level. It does depend largely on whether the student is interested in what is being taught. A big aspect in students' learning and achievement is motivation. One reason why the participants are persistent and successful as STEM majors is because their interest in the STEM fields began before they were enrolled in undergraduate classes. Most spoke highly of their high school instructors who used methods that caught and held their interests. The instructors helped them to apply what they learned to their everyday lives, instead of gaining a shallow knowledge of many topics.

There is a need therefore to significantly improve how science and math are taught in the U.S. Although it may not be written in the curriculum, educators need to unpack the curriculum so that much time be given to the inquiry process, which involves learning to plan and carry out investigations, while finding evidence for their argument (NAS, 2011). Data shows that students who learned through inquiry developed a love for their field of study, and were therefore persistent and successful. Of such importance is the use of the inquiry method in STEM education that even those students who completed only two science classes in high school majored in undergraduate STEM fields and were successful, while students who completed four or more advanced science courses in high school are struggling to successfully complete their STEM courses. Likewise, postsecondary instructors must do their part in helping to motivate their students though learning by inquiry.

Educators must also view their students as individuals and teach them as such. Some students desire or need individualized instruction in order to fully understand the process. That time should be planned into instructors schedule both at the precollege and undergraduate levels. All the interviewees praised or spoke highly of "recitation" an out of regular classroom time where students meet with instructors or graduate students and mentors to discuss and work on material that was not fully grasped during the class session. They were given more time and opportunity to ask questions and engage in investigations, therefore gaining deeper understandings and appreciation for the subject.

Precollege curriculum planners must begin to focus on what students should be able to do before enrolling in college, or by the end of high school. The STEM curriculum requires depth instead of breadth. Too often students are required to learn a large quantity of science material without given the opportunity to learn how to do science (NAS, 2011). Science is best learned by doing (Owens, 2009). When curriculum writers include how to do science into the science framework, especially at the K-12 levels, then students will begin to make connection with their world through science and begin to appreciate it. The participants who learned by doing, reported that it was easy to transfer what they learned to what they were learning in college. Further, the inquiry or hands-on method of teaching helped them to be able to apply the theory to the practical thus, making the material easier to understand and remember. On the other hand, the participant who complained that he was not given the opportunity to explore for himself, but was told everything by his teachers, could not relate what he learned in his high school advanced science and math classes to what he was learning during his undergraduate years.

Hence, precollege STEM curriculum writers and instructors must begin to focus on helping students enjoy science enough that they engage in scientific inquiry in and out of school, be able to think critically about science related issues, and build on the skills, knowledge and experiences acquired in their precollege years during their college career. Once in college, the focus of the curriculum and assessment developers should focus on teaching and learning that is relevant for the twenty-first century. It is reported that in 2007, underrepresented minorities comprise only 17.7 percent of students enrolled in undergraduate college STEM courses, 14.6 percent in masters programs, and 5.4 percent in doctoral degree programs (NAS, 2011). By adhering to the above academic and professional practices, underrepresented minorities will be more likely to have a part in America's STEM pipeline.

Theory

Tinto and Pusser's (2006) model of institutional action for student success and Owens (2009) model for improving science achievement, were the conceptual framework for this study. Tinto and Pusser (2006) proposed a model that discusses the need for postsecondary institution to take action in increasing the rate of student persistence and success. Since, according to the authors, an institution can only control what goes on internally, the model focused on actions within the institution at it shapes events within the institution.

One condition that helps to shape an institution is the high expectation of students and faculty (Tinto & Pusser, 2006). This theory was confirmed by some of the participants in this study. More than half the number of interviewees noted that the high expectations of their instructors cause them to work very hard while attending to details. The expectations expressed by faculty for student performance impact the quality of the students' effort and work.

Another condition noted by the authors which were identified to a great extent in this study is engagement or involvement. The participants stated that continual engagement with faculty and peers is extremely important to their success and persistence. Hence, the greater the degree of student engagement with peers, faculty and other people on the college campus, the more likely they are to persist. These findings are especially pertinent for institutions that educate a large body of underrepresented minority students who commute. It is important that institutions include in their curriculum, activities that meet these conditions.

Owens (2009) contends that students in the United States fail to learn science for one or all of three reasons: a) Our system of education ignores the research about how students learn science; b) teachers are aware of the research but fail to implement it in their classroom; or c) the standards, curriculum and education policy of the United States are not conducive to effective science teaching (Owens, 2009, pp. 49-50). These statements confirm findings of this research. Based on the participants' responses, some high school teachers engaged them into meaningful learning, while others did not. While the majority of the students contended that they studied a curriculum that increased their skills, knowledge and understandings in science and math, others did not think that the curriculum was as in-depth as it should have been. Hence, the theories proposed by these authors were confirmed in the research.

Research

The importance of STEM to the United States and the world has been documented in reports for over half a century. However, not many studies have examined how the precollege curriculum directly affects underrepresented minority undergraduate STEM success. The studies that do are limited to small sampling of students from a single college. It is therefore recommended that longitudinal studies, not unlike the Toolbox (Adelman, 1999), be done. Such research would not only uncover the relationship between precollege STEM curriculum and postsecondary success, but may assist in the success and persistence of underrepresented minorities in STEM majors.

It is also recommended that follow-up studies be done to unravel why underrepresented minorities who enroll in postsecondary STEM majors are not successful and persistent. Here again, longitudinal studies with samples representing African Americans, Hispanics, and Native Americans are recommended. Nontraditional students make up about 4.7 million of 14.9 million undergraduate students enrolled in America's colleges and universities. (NCES, 2007, Table 178). Adult learning theories (Knowles, 1968; Merriam, 2003; Mezirow, 2003), states that adults learn differently than children. Since some of these learners are underrepresented minorities who could help to close the gap in the STEM pathway, it is hereto recommended that studies exploring the success and persistence of nontraditional learners in college STEM majors be done.

Tinto and Pusser (2006) contended that there is a disparity in the persistence and success rate of low-income students in comparison to high-income students, noting that the need exists for an institutional model of action which will impact institutions to improve student persistence and success. They stated, "Institutions that are committed to the goal of increasing student success especially among low-income and underrepresented students, seem to find a way to achieve the end" (Tinto & Pusser, 2006, p. 6). Since the participants in this study were from families of varying income levels, it is recommended that a study comparing the persistence and success of low-income in comparison to high-income underrepresented minorities be done. This would further confirm or disprove the notion that STEM students from higher socioeconomic backgrounds are persistent and successful because they acquire precollege education in areas or schools where a more rigorous STEM curriculum was studied.

Summary

This investigation provided insight into the factors contributing to the success and persistence of underrepresented minority STEM learners. The U.S needs to ensure that underrepresented minorities are represented in the STEM workplace. This will only be accomplished if a higher percentage of them are successful in college STEM programs. There is also a greater need for this people group at the master and doctorate academia. Participants of this study provided data that shows how these academic goals can be reached by all African Americans, Hispanics, and Native Americans. It has now become the responsibility of all educators from K-12 to the postgraduate level, to ensure that these students get the STEM knowledge and skills required to be involved in the STEM pipeline and be prepared for the future STEM workplace. Although not impossible, it is more difficult to succeed in college STEM programs with a lack in precollege preparation. Accordingly, students who are inadequately prepared may require additional support from peers, family, faculty and college administration.

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APPENDIX A. Consent Form

My name is Teresa P. Blair and I am a doctoral learner in the School of Education at Capella University. I am doing a research study called Exploring Factors Affecting the Persistence and Success of Underrepresented Minorities in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Majors.

This research is being supervised by Dr. Joshua T. Fischer. I would like to invite you to participate in this research study. The main purpose of this form is to provide information about the research so that you can make a decision about whether you want to participate. If you choose to participate, please sign in the space at the end of this form.

WHAT IS THE RESEARCH ABOUT?

The purpose of this study is to discover why some underrepresented minority college students are successful in their STEM fields. In particular, focus will be placed on their precollege STEM preparation.

WHAT DOES PARTICIPATION IN THIS RESEARCH STUDY INVOLVE?

If you decide to participate in this study, you will be asked to complete a one-on-one interview. You will be audio taped during your participation in this interview which will be kept safely until the end of the study.

WHY ARE YOU BEING ASKED TO PARTICIPATE?

You have been invited to participate because you are a STEM major, have completed two or more college STEM course(s), **or** you are presently enrolled in one or more college STEM course(s).

WHAT ARE THE RISKS INVOLVED IN THIS STUDY?

Although no study is completely risk-free, we don't anticipate that you will be harmed or distressed by participating in this research. If you find yourself becoming uncomfortable, you may stop your participation at any time.

ARE THERE ANY BENEFITS TO PARTICIPATION?

We don't expect any direct benefits to you from participation in this study. However, your participation will help to better prepare high school students for success in college STEM courses.

WHAT HAPPENS IF THE RESEARCHER GETS NEW INFORMATION DURING THE STUDY?

The researcher will contact you if he/she learns new information that could change your decision about participating in this study.

HOW WILL THE RESEARCHER PROTECT PARTICIPANTS' CONFIDENTIALITY?

The results of the research study will be published, but your name or identity will not be revealed. In order to maintain confidentiality of your records, the researcher will identify you by sequence numbers and/or letter codes only.

As a mandated reporter, if I believe you are planning to harm a vulnerable child or adult or if you are planning to harm yourself, I am required file a report. If this happens, I will tell my research supervisor your name and my concern. You will be contacted if this happens.

WHAT HAPPENS IF A PARTICIPANT DOESN'T WANT TO CONTINUE IN THE STUDY?

Participation in this study is voluntary. If you choose not to participate or if you choose to withdraw from the study, you may do so at any time. There will be no consequence. It will not affect your affiliation with Clark Atlanta University.

WILL IT COST ANYTHING TO PARTICIPATE IN THE STUDY? WILL I GET PAID TO PARTICIPATE?

You will not be paid or given any financial benefit to participate in this study.

WILL PARTICIPANTS BE COMPENSATED FOR ILLNESS OR INJURY?

You are not waiving any of your legal rights if you agree to participate in this study, however no funds have been set aside to compensate you in the event of harm. If you suffer harm because of this research project, you may contact me, at tpondie@gmail.com, phone - 770-873-9859, or Dr. Cass D. Parker, Chemistry Department Chairperson, Clark Atlanta University (CAU) at cparker@cau.edu or at 404- 880-6858. You may also contact the Capella Human Research Protections Office at 1-888-227-3552, extension 4716.

VOLUNTARY CONSENT

By signing this form, you are saying that you have read this form or have had it read to you. You are also saying that you understand the risks and benefits of this research study and that you know what you are being asked to do. The researcher will be happy to answer any questions you have about the research. If you have any questions, please feel free to contact Dr. Cass D. Parker, Chemistry Department Chairperson, Clark Atlanta University (CAU) at cparker@cau.edu or at 404- 880-6858, or you may contact Joshua T. Fischer PhD, my mentor, at Capella University, Minneapolis, MN. Email - Joshua.Fischer@faculty.capella.edu

If you have questions about your rights as a research participant, the Capella Human Research Protections Office is available to help. If you have any concerns about the research process or the researcher, please contact us at 1-888-227-3552, extension 4716. If there are any unexpected problems with the research please also be sure to contact us. Your identity, questions, and concerns will be kept confidential.

Note: By signing below, you are telling the researcher "Yes," you want to participate in this study. You may choose to withdraw this consent at any time. Please keep one copy of this form for your records.

Your Name (please print):____

Your Signature: ____

Date: __________________________

INVESTIGATOR'S STATEMENT

I certify that this form includes all information concerning the study relevant to the protection of the rights of the participants, including the nature and purpose of this research, benefits, risks, costs, and any experimental procedures.

I have described the rights and protections afforded to human research participants and have done nothing to pressure, coerce, or falsely entice this person to participate. I am available to answer the participant's questions and have encouraged him or her to ask additional questions at any time during the course of the study.

Investigator's Signature: *Teresa P. Blair*

Investigator's Name: Teresa P. Blair

Date: 11/5/2010.

Research Site(s) Approval

The following institution has granted the researcher access to their participants and/or facilities:

Name: Clark Atlanta University. Approval Date: 12/14/2010. Approval Code/Number: HR2010-11-371-1/A

Capella's IRB Approval

This research has been approved by Capella University's Institutional Review Board. Approval number: 186683-1; Effective dates: From: 12-20-2010 to 12-20-2013.

APPENDIX B. Interview Protocol

Sequence Number________________

Time of interview________________

Place of Interview________________

A number called the participant's sequence number will be assigned to the participant based on the order or sequence in which they were interviewed. The numbers will range from 001 to 010.

1. a. How many science courses have you taken in high school?

   b. Which courses best prepared you for your college career?

   c. How did they help to prepare you?

2. a. How many mathematics course have you taken in high school?

   b. Did they prepare you for the college math and science courses you took so far?

   c. In what way(s) did they prepare (or not prepare) you?

3. a. Did you complete technology courses (classes) in high school?

   b. How would you describe the courses taken?

4. How have the math and science courses taken in high school affected your success and persistence in your chosen STEM major?

5. Do you think that the curriculum (content, skills, and tasks) completed in high school has prepared you for:

a. the problem solving skills you need to succeed in college courses?

b. the critical thinking skills you need to succeed in college courses? Explain.

6. Are you using the knowledge and skills learned in your high school science classes in your college courses now? (If yes, how are you using them? If no, why aren't you using them?)

7. Are you using the knowledge and skills learned in your high school mathematics classes in your college courses now? (If yes, how are you using them? If no, why aren't you using them?)

8. a. What would you say are the best types of instructional methods or strategies that your high school math and science teachers used?

b. Why do you categorize them as the best types?

9. How have the teaching strategies used by your college instructors helped or not helped you to succeed in your college courses?

10. How do the teaching strategies used in your college courses compare with those used in your high school previously? (That is, do the college strategies help you understand the material better or worse than the high school strategies?)

11. What kinds of learning experiences did you have in high school that are useful to you now?

12. What types of learning experiences from your college STEM education do you think will be most useful to you in your job and/or career?

13. Do you think that your college curriculum when completed will adequately prepare you for the STEM workplace? Explain.

14. a. What types of faculty support are most helpful to your success in STEM courses?

b. How or why are they helpful?

15. a. Overall, on a scale of 1 to 10, how would you rate the high school curriculum as compared with the curriculum used in your college courses?

b. Why did you give that rating?

16. Do you have anything else you would like to add about your high school and college STEM curricula's effect on your college success and persistence or about this interview?

Thank you very much for your time and cooperation. You have been very helpful. Should you have further questions, comments or concerns, please feel free to contact me by email at tpondie@gmail.com or by phone at 770-873-9859.

APPENDIX C. Recruitment Speech

My name is Teresa Blair and I am a doctoral learner in the School of Education at Capella University. I am doing a research study called Exploring Factors Affecting the Persistence and Success of Underrepresented Minorities in Undergraduate Science, Technology, Engineering, and Mathematics (STEM) Majors. I am here to invite you to participate in the study. The consent forms contain much information about your participation in the study. In order to participate, you must have completed, or are in the process of completing STEM courses here at CAU or from another university. After you have read the entire form, please ask me any questions that may be of concern to you.

To participate, you will be asked to complete a face-to-face interview, which will be conducted here on the college campus. Your identification will not be released to anyone, and I will use a number instead of your name as a way of identifying you. The number will be based on the order or sequence in which you were interviewed. If you prefer, I can use your first or fictitious name instead of a number. You may now read the form and then I will answer your questions. If you have further questions you may also ask Dr. Parker whether face-to-face or by email, or by contacting me via email or phone.

Thank you.