Factors that Influence Community College Students' Interest in Science Coursework

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Abstract of the Dissertation

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There is a need for science education research that explores community college student, instructor, and course characteristics that influence student interest and motivation to study science. Increasing student enrollment and persistence in STEM is a national concern. Nearly half of all college graduates have passed through a community college at some point in their higher education. This study at a large, ethnically diverse, suburban community college showed that student interest tends to change over the course of a semester, and these changes are related to student, instructor, and course variables. The theoretical framework for this study was based upon Adult Learning Theory and research in motivation to learn science. Adult Learning Theory relies heavily on self-directed learning and concepts of andragogy, or the art and science of teaching adults.

This explanatory sequential mixed-methods case study of student course interest utilized quantitative data from 639 pre-and post-surveys and a background and personal experience questionnaire. The four factors of the survey instrument (attention, relevance, confidence, and satisfaction) were related to motivation and interest by interviewing 12 students selected through maximum variation sampling in order to reach saturation. Qualitative data were collected and categorized by these factors with extrinsic and intrinsic themes emerging from personal and educational experiences. Analysis of covariance showed student characteristics that were significant included age and whether the student already held a post-secondary degree. Significant instructor characteristics included whether the instructor taught full- or part-time, taught high school, held a doctoral degree, and had pedagogical training. Significant course characteristics included whether the biology course was a major, elective, or service course; whether the course had a library assignment; and high attrition rate. The binary logistic regression model showed six significant variables that predicted increased student interest: older students, previous degree holders, students that took courses at night rather than during the daytime, students who were taught by instructors who taught high school, instructors who taught part-time, and students who had a non-STEM major. Methodological triangulation ensured that the research questions were adequately addressed, as qualitative data corroborated and provided insights for quantitative results.

These findings imply that interventions such as implementation of professional development, specifically in andragogical training for instructors and support personnel, are necessary in order to properly address the needs of community college students. Policy makers need to ensure that proper academic and financial counseling systems are in place for students enrolled in these science courses. Students were affected by past experiences and required support from others in order to increase their interest and motivation to study science. This study will inform efforts to help community college students persist in the pipeline to join in the STEM workforce or transfer to four-year colleges.

Dedication

This is dedicated to my parents, who have always shown their immense pride in my accomplishments, taught me to work hard and to put my best effort toward everything that I do. This achievement is a consequence of and a testament to the fantastic job that they did. My life could not be any better, and I owe it all to them. I am sure this achievement is a source of great joy for my mother. I only wish I could enjoy that delighted look on my father's face followed by a big hug just once more.

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Chapter 1

Introduction

1.1 Thesis

Community college students' interest and motivation to study science are important constructs in the field of science education research. Community colleges are essential in preparing skilled science, technology, engineering and mathematics (STEM) professionals. Their student populations consist of a diverse group of individuals with an array of life circumstances and personal backgrounds, and the factors that affect their choices need to be explored. Community colleges focus on teaching and providing opportunities to many who are non-traditional students; therefore, personal, course, and instructor factors related to students' interest and motivation are relevant to science education research.

This study investigates the effects that community college instructors and course characteristics had on students' interest in and motivation to study science, as well as students' background factors that may have influenced these attitudinal constructs. This chapter will outline the research questions and provide background that highlights community colleges' role in our nation's educational system. A brief summary of factors affecting persistence and predicted changes in the job market and population will also be discussed to provide a rationale for this work, which will contribute to the national discussion on improving STEM participation.

1.2 Research Questions

This study provides insights into why community college students are motivated to study science and choose to major in STEM disciplines. Data regarding the backgrounds of community college students were gathered, specifically, data revealing why so many were choosing health-related careers and enrolling in sciences courses even though some stated they had low confidence, interest, and motivation to study science. Exploration of the various personal factors that influenced this particular demographic at an ethnically diverse, suburban, multi-campus community college in New York State is important to identify constructs that affect academic decision making. Several comparisons were done among the cohorts of different biology courses to measure the effects of student variables on interest, motivation, and confidence to study science, as well as how student outcomes were influenced by individual instructor and course characteristics.

To address how specific background and academic factors were correlated to student interest, confidence, and motivation, the following research questions were explored in this study:

1. How were the personal characteristics and backgrounds of community college students related to their interest, confidence, and motivation to enroll in science courses and pursue science-related careers?

2. How were student interest, confidence, and motivation to study science related to instructor characteristics?
3. How was the type of biology course in which community college students were enrolled related to student interest, confidence, and motivation?

This mixed methods explanatory sequential study utilized both quantitative and qualitative methods to answer the research questions through pre- and post-surveys, background factors and personal experience questionnaires, and semi-structured interviews. The data and insights gained are valuable for serving the needs of community college students through more informed policies regarding recruitment, retention, remediation, bridge programs with local high schools, strengthening articulation agreements and future program development, and hiring faculty. Findings may also promote changes at the primary and secondary education levels to expose students to early scientific experiences; this has been shown to develop interest and confidence in studying science (Bettinger 2010; Tai, Lui, Maltese, & Fan, 2006; Wang, 2013).

To answer these research questions, an ethnically diverse sample of community college students was surveyed at the beginning and end of their enrollment in biology coursework. The researcher measured whether their interest, confidence, and motivation to study science changed, and, if so, whether they were influenced by various instructor characteristics, type of course, and personal characteristics (such as full-time and part-time student status, educational background, and gender).

Investigation of community college students' experiences during their secondary and post-secondary education, background factors, and motivations for enrolling in the course were collected through a questionnaire. Through interviews, the perspectives of a select sample of students were recorded and coded. Students were asked about memories of science and pre-college science experiences, as well as aspects of their personal and academic lives that affected their motivation. The qualitative data from interviews were analyzed by performing open, axial, and thematic coding of the interview transcripts regarding their science experiences. Studying past experiences of those persisting in STEM may elucidate how to improve STEM education in K-12 education and at the community college level.

1.3 Factors that Influence Community College Students

Identification of personal characteristics and experiences that influence student motivation to study science is of great interest, yet there is a lack of peer-reviewed literature specific to community college students studying science. Determining the impact of background factors on student motivation in higher education is a revealing area of research in need of further study (Sogunro, 2015). The need for research in the community college context is important to provide knowledge regarding how to increase participation and persistence in STEM.

Community college enrollments reveal several issues related to socioeconomic considerations. In comparison to traditional college students, community college students have been more likely to be married and caring for dependents (Berkner & Choy, 2008), come from low-income families (Horn & Nevill, 2006), enroll part-time (Provasnik & Planty, 2008), and commute (Cohen & Brawer, 2003). Students whose families were low-income comprised 50% of the two-year college population (National Academies of Science [NAS], 2016). Underrepresented minority enrollment in two-year public institutions has been disproportionately higher than at other institutions (National Science Foundation [NSF], 2011). In a study of 378 two-year and four-year colleges in urban, suburban and rural settings, underrepresented minorities starting out at community college had a completion rate (certificate, associates or bachelor's degree) of 24% compared to other students, whose completion rate was 38%. Only 7% of underrepresented minorities and low-income individuals completed a bachelor's degree within ten years (The Education Trust, 2009).

Community colleges provide second chances to those who did not flourish earlier in their education and they provide new possibilities for diverse populations. The U.S. Census Bureau projected that by 2060 the Non-Hispanic White population will be 44% of the overall population (Colby & Ortman, 2015). Understanding the differential effects of various educational experiences is particularly beneficial for improving the performance of underrepresented minority students who have been traditionally underserved in educational settings (Wang, 2013).

Community college students have also been influenced by instructor characteristics (Starobin & Laanan, 2008) and relationships with their instructors (Barnett, 2011; Bensimon, 2007; Braxton, Hirschy, & McClendon, 2004; Crisp, 2009; Deil-Amen, 2011; Jaeger & Eagan, 2009). Most community college instructors have earned at minimum as master's degree in their field of specialty but not necessarily a degree in education (American Association of Community Colleges [AACC], 2015a; Minter, 2011; Outcalt, 2002). Higher education faculty may have little knowledge about student learning theories and teaching methodologies related to pedagogy and andragogy (Minter, 2011). Approximately two-thirds of community college faculty are part-time instructors (Provasnik & Planty, 2008), and therefore may be less integrated into the campus culture (Schuster, 2003), and less likely to be invited to participate in professional development activities (Roueche, Roueche, & Milliron, 1995). Due to the high number of part-time faculty, concerns have been expressed regarding the quality of education they provide (Eagan & Jaeger, 2009; Jacoby, 2006). Moreover, in comparison to their full-time counterparts, part-time faculty are more likely teach remedial, introductory, and general education courses (Schuster & Finkelstein, 2006).

Community college students are influenced by their relationships with their instructors. Specifically, faculty may help increase student confidence, cultivate academic skills, and disseminate important information about transferring to four-year institutions (Bensimon, 2007). The overall persistence of community college students was increased when students were supported, mentored and recognized by faculty (Barnett, 2011; Braxton et al., 2004; Deil-Amen, 2011). Instructor characteristics are important considerations when investigating community college students' educational experiences, confidence, interest and motivation to study science.

1.4 Community Colleges and Their Role in U.S. Education

As the U.S. has grown and progressed since the turn of the twentieth century, so have community colleges. Not only have community colleges grown in number of institutions and enrollment, they have also improved the quality of life for many Americans. During the Great Depression, community colleges were instrumental in producing skilled workers to revitalize the economy during one of the most challenging times in history. Community colleges grew to provide associates degrees and subsequently established the foundation for bachelor's degrees and graduate degrees. Among college graduates, 46% have attended community college at some point during their post-secondary education (AACC, 2015b). Development of greater interest and increased motivation to study science is an important consideration for community colleges as they seek to increase STEM enrollment, persistence and degree attainment.

1.5 National Need for Increased STEM Participation

Enrollment in STEM is currently insufficient to meet the economic needs of the U.S. The National Governors Association (NGA) projected that in 2018 at least 8 million jobs will be available to college graduates in STEM fields (NGA, 2011). According to the New York State Department of Labor (NYSDL), STEM employment increased 11.4% from 2004 to 2014, compared to non-STEM related career growth of only 4.5% (NYSDL, 2009). STEM careers are growing 2.5 times faster than other fields in the state (NYSDL, 2014). In 2015, STEM professionals earned 85% more than non-STEM-related workers (NYSDL, 2015a). Of the top 25 fastest growing occupations in New York State, 21 of them were STEM careers (NYSDL, 2015b).

Community colleges are often seen as the best and main resource for preparing Americans for the current job market, as nearly half of all jobs nationally have been classified as “mid-skill” (NGA, 2011). A 33% increase in STEM majors is required to meet these needs (President’s Council of Advisors on Science [PCAST], 2012). Community colleges annually enroll over 8 million students, therefore, these institutions are valuable in developing competent STEM professionals (National Research Council [NRC], 2012). Community colleges have been the gateway to employment and social mobility for many (Morest, 2013). However, increased attention to workforce predictions has focused on demand, or quantity of programs, rather than quality and student support systems (NAS, 2016). This study aims to shed light upon ways in which the community college experience may be improved for potential STEM graduates.

Determining the reasons why individuals participate in STEM is complex. Nearly half of all college students who initially majored in STEM ended up changing their majors, whereas only 14% of community college students that started out in STEM were still STEM majors at the time of their last enrollment (NRC, 2012). According to PCAST, less than 40% of those starting as STEM majors [at 4-year institutions] completed a STEM degree (PCAST, 2012). Students’ reasons for attrition were listed in three categories: 1) for high performing students: “uninspiring introductory courses”; 2) for low performing, high interest students: “difficulty with math”; and 3) for underrepresented students: “unwelcoming atmosphere from faculty in STEM courses” (PCAST, 2012, p. i). These factors demonstrate that an investigation of how to increase student interest and motivation to study science in community colleges is overdue.

1.6 Factors Influencing Student Motivation for STEM Participation

Motivation to participate in STEM can be can be influenced by the extent of meeting the psychological needs of competence, autonomy and social relatedness (Ryan & Deci, 2000). Enhanced teaching methodologies can improve student learning and STEM persistence (PCAST, 2012). Engaging students in the process of undergraduate research has been one of the most effective strategies to improve undergraduate STEM education (NSF, 2014). Interactions with faculty and advisors have encouraged students to study STEM fields (Wang, 2013), and motivation requires supportive conditions in order for it to be sustained (Ryan & Deci, 2000). Tinto (1993) stated that although social integration in community college is relevant, academic integration is more important to student persistence.

Community college students who transferred to four-year institutions stated that supportive relationships with individual community college faculty were instrumental in their success (Bensimon, 2007). Rendón (1994, 2002) postulated that “validation” (faculty initiated interactions with students that fostered feelings of self-worth and efficacy) was more important than integration for student success. Consequently, a student may choose to change her major due to interactions with instructors or due to what she has learned or experienced.

Developing interest in science at an early age has been shown to be an important factor for those who have chosen STEM careers. Students that had pre-college science-related career goals were more likely to attain them (Tai et al., 2006). Studies have shown that a variety of teaching styles were vital to spark student interest in science at the elementary, junior high, and high school levels (Myers & Fouts, 1992; Pilburn & Baker, 1993). Exposure to science in positive and encouraging ways during elementary and secondary education has given students a foundation on which to build in higher education (Bass, 2012). Teachers have the ability to affect science interest during primary, secondary, and post-secondary education.

1.7 Factors Influencing the Motivation of Adult Learners

Adults possess ways of learning that are often different from younger learners (Bass, 2012). Adult learners are diverse and have more experiences than children; therefore, the adult educator must develop appropriate teaching approaches to meet their needs (Crawford, 2004). However, the complexity of psychosocial interplay between personality, context and environment for the adult learner is often ignored by researchers and practitioners (Brookfield, 1986). In a study of 203 individuals enrolled in master's degree programs, eight major themes emerged as important motivating factors for adult learners (Sogunro, 2015). These factors, listed in descending order of importance, were: 1) quality of instruction, 2) quality of curriculum (content/syllabus), 3) relevance and pragmatism, 4) interactive classrooms and effective management practices, 5) progressive assessment and timely feedback, 6) self-directedness (learner autonomy), 7) conducive learning environment, and 8) academic advising practices (Sogunro, 2015). The majority of these factors are dependent upon skills and qualities that the instructor possesses.

1.8 Summary

Interest in science needs to be explored in order to find ways to reverse the trend of low recruitment and retention in STEM. Community college students, whose backgrounds tend to be more diverse and complicated than the traditional college student, must receive special attention to improve their persistence. The need to be educated as an adult by those with related instructional training is appropriate for community college students. The instructor's influence on student interest in science, even in the subtlest of ways, may be an essential component in learning how to help increase interest, confidence, and motivation to study science. Chapter 2 details the factors that affect motivation, national needs for skilled STEM workers, and the role that community colleges have played in educating them.

Chapter 2

Literature Review

2.1 Introduction

This chapter outlines important factors that have affected student interest and motivation to study science and enroll in STEM-related careers. The first section outlines a brief history of community colleges, current demographics, and their importance in society for providing social mobility. The theoretical framework will be discussed, and the notion that adult community college students have different needs than other learners. The research literature review continues with the history of attitude and motivation research followed by descriptions of the terminology utilized in the field, especially interest, as a construct of motivation. Factors affecting females in science are discussed since they comprise a large portion of the population that was surveyed. The effect that the teacher has on motivation is important, therefore, teacher preparation is addressed. Reasons for attrition from STEM, achievement and persistence are discussed. Some of the major challenges and obstacles that community college students face are summarized.

2.2 A Brief History of Community Colleges

Most sources recognize Joilet Junior College founded in 1901 in Illinois as the oldest public two-year college still in existence (AACC, 2015b). Early discussions centering on formation of such colleges occurred in Saginaw, MI, in 1895, and in Greeley, CO, in the 1880's by secondary schools and universities (Hogan et al., 2002). The term "junior college" was first used in the late 1890's by William Rainey Harper, the president of the University of Chicago, to describe what would be a lower division of the university allowing freshmen and sophomores to fulfill their general education requirements. More specialized courses were taken at the university; however, if coursework at the university were not completed, students would be granted an associate's degree in arts, philosophy or science for completing these courses. Harper, as well as other American university leaders, sought to pattern junior colleges after the German university system, which emphasized specialized studies (Hogan et al., 2002).

High school graduates were increasing in number and high school administrators were encouraged to create post-secondary education and opportunities for these graduates. Additionally, some small and private four-year colleges could not maintain enrollment in upper level courses and began to reorganize as junior colleges. Initially, junior colleges were seen as extensions of the high school and were partly collegiate, partly vocational, and partly terminal degree earning institutions (Jurgens, 2010).

Technical colleges were initially developed in the early 1900's to meet the need for skilled workers for the massive industrialization of the nation and mechanization of agriculture in the United States; hence, the Associate's in Applied Science was established for such technical and vocational programs (Hogan et al., 2002). By 1920, approximately 74 community colleges existed in the U.S., and due to the initiation of the Carnegie Unit, transfer of credits from community college to four-year colleges and universities was possible (Jurgens, 2010).

By 1930, vocational and technical programs had a permanent root in two-year colleges. During the Great Depression, and in the decade that followed, these institutions gave education and job training to many who were unemployed throughout the country (AACC, 2015b). By 1946, nearly 300,000 students were enrolled in 648 accredited two-year institutions, of which less than half were publically funded (Hogan et al., 2002). After World War II, consumer industries replaced military needs and created jobs as well as the need for additional skilled workers (AACC, 2015b).

In 1947, President Truman convened the U.S. Commission on Higher Education that generated the Truman Commission Report, also known as the *Higher Education for an American Democracy Report*, where the term "community college" first appeared (Jurgens, 2010). Due to the federal GI Bill, a financial scholarship established in 1944 for military service in World War II, the Commission decided that public, locally-controlled, two-year community based institutions would be the most logical providers of opportunities in higher education for Americans. The U.S. government advocated for providing equal, post-secondary educational opportunities through public community colleges until the 1970's. Currently, the federal government financially supports students attending community colleges (Hogan et al., 2002).

Baby boomers coming of age in the 1960's and the robust economy of the U.S. contributed to the construction of many new facilities. During the 1960s, 457 more public community colleges were opened, and numbers steadily increased through the years; there are 1,123 community colleges in the United States today (AACC, 2015b). Community colleges are uniquely accessible in that 90% of Americans live within 25 miles of one, and community colleges are already serving large minority populations, which continue to grow in number (NGA, 2011).

Although each community college has its own mission, commonality exists in open access and low tuition, as statistics show that community college tuition per year on average is about one-third the cost of a public in-state four-year college (AACC, 2015b). Traditionally, the missions of community colleges include most, if not all, of the following: lower division collegiate education, occupational and technical training, general education programs, developmental and remedial services, student services (job placement and career counseling, development courses and workshops that build personal, social and academic skills), and community and general services (Adult Basic Education-ABE, General Equivalency Diploma-GED, English as a Second Language- ESL and College Level Examination Program- CLEP) (Hogan et al., 2002).

2.3 Community Colleges Today

In 1992 the American Association of Community and Junior Colleges dropped "junior" from its name (AACC, 2015b). Although development of new community colleges seems to have leveled off, enrollment continues to grow faster than enrollments at four-year institutions, due in part to lower cost of tuition (AACC, 2015b), and in part to dual enrollment and four-year institutions becoming increasingly competitive (Jurgens, 2010). In 2010, community colleges enrolled 64% of all part-time students and 26% of all full-time students in the U.S. (Aud et al., 2012).

Community colleges typically enroll non-traditional students. The average age of a community college student is 28, with 49% of students in the age range of 22-39. Women comprise 57% of community college students and 45% are identified as minorities. Community colleges' enrollments include 36% first generation college students, with 17% being single parents and 12% students with disabilities (AACC, 2015b). With low tuition, close proximity to work and home, flexibility in scheduling, and open access, community colleges are attractive to a wide variety of students, particularly those who are also managing a family (Starobin & Laanan, 2008; Tsapogas, 2004).

The correlation between student status and employment status is important to consider when looking at achievement, graduation rates, and attrition. In 2011-2012, 22% of community college students were both full-time students and full-time workers, while 40% were enrolled full-time and worked part-time; 41% of part-time students worked full-time and 32% of part-time students worked part-time (AACC, 2015b). Graduation and success rates for community college students have typically been measured over a six-year period (AACC, 2013a), in part due to how much theses students were working outside of school time, as well as other personal and familial responsibilities.

2.4 Theoretical Framework

Adult Learning Theory. The theoretical framework for this study is based upon Adult Learning Theory and research in motivation to learn science. *Adult Learning Theory,* developed by Malcolm Knowles (Knowles, 1980), states that adults must be interested in a subject for their attention to be retained and therefore learn. In this theory the term andragogy, "the art and science of helping adults learn," is more relevant than pedagogy since pedagogy refers to the teaching of children. Teaching adults is different than teaching children, and "adults who have been away from systematic education for some time may underestimate their ability to learn and this lack of confidence may prevent them from applying themselves wholly" (Knowles, 1980, p. 41). Educators cannot simply apply what is known about how to teach children to educating adults (Bass, 2012).

Andragogy stems from American Association for Adult Education publishing the *Journal of Adult Education* from 1929-1948, which contained articles by teachers of adults who felt they were more successful by treating adult students differently than suggested in traditional pedagogical models, in which the teacher is responsible for determining what the student learns from a set curriculum (Knowles, 1980). A major distinction between pedagogy and andragogy is the sense of self one has. Children view themselves as dependent on others to make decisions for them, and when they become adults they view themselves as independent and self-directed (Caruth, 2014). Knowles cited Havinghurst's definition of the three phases of adulthood, with "early adulthood" beginning at age 18 (Knowles, 1980). Nearly all community college students are classified as adults by that definition. Therefore, Adult Learning Theory and the concept of andragogy applies to all community college students.

An *adult*, or non-traditional student, is also classified by the National Center for Education Statistics (NCES, 2014) as a student meeting one of the following seven criteria: delayed enrollment, part-time for at least part of the year, works full-time (35 hours per week), considered financially independent for financial aid eligibility purposes, has dependent(s) that are not a spouse, single parent, or not possessing a high school diploma but possibly a GED or other certification. In addition to variation in ages, community college students come from a wide variety of backgrounds and life circumstances that make many of them different than the traditional college student.

The four assumptions of Adult Learning Theory are: 1) self concept of the learner, 2) role of learners' experience, 3) readiness to learn, and 4) orientation to learning

(Knowles, 1980). These constructs are operationally defined as follows:

- *Self-Concept of the Learner* is viewing education as a change in self-concept and that the process is the shared responsibility of teacher and learner, whereby the student is moving from a dependency on an instructor towards self-directed learning.
- *The Role of Experience* states that as one ages she has gathered a reservoir of experience, and she tends to find learning from experience to be more meaningful than passivity.
- *Readiness to Learn* occurs when an individual needs to learn something new to deal with real life problems. The instructor facilitates learning by providing tools to help the learner move from a standardized curriculum towards application to real life.
- *Orientation to Learning* refers to the learner viewing education as a process to help him fulfill his life's potential, in that the learning is less content and subject-centered and more performance-centered.

Knowles stated that a fundamental aspect of andragogy (and, therefore, Adult Learning Theory) was self-directed learning, defined as:

> A process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating their learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies and evaluating learning outcomes (Knowles, 1975, p. 18).

Knowles (1984) theorized that the learner would be more inclined to stay dependent when the educational setting is structured, though she should be learning to become more autonomous. Knowles' work was influenced by the work of many researchers before him; one was Carl Rogers (Blondy, 2007), who believed that educators could not actually teach anything, rather, educators could facilitate the process of learning (Rogers, 1967). Rogers suggested that a learner could become more self-directed with less emphasis on a strict curriculum (1967). Knowles (1984) stated that as learners mature they are able to become more self-directed and wise because of experience and knowledge gained.

Canning (2010) described a progression from pedagogy to andragogy to heutagogy in which the learner becomes more mature and autonomous in his learning process as instructor control decreases. Andragogy relies heavily on the idea that learning becomes more *self-directed* as we become adults (Blaschke, 2012). *Heutagogy* is the study of *self-determined* learning (Hase & Kenyon, 2001). In heutagogy, the learner is not only active, but proactive. In this method of learning, an instructor facilitates the process but the learner determines *what* and *how* she will learn; therefore, curriculum and assigned learning activities become irrelevant (Hase & Kenyon, 2007). Heutagogy is an extension of andragogy and the two can be viewed on a continuum (Blaschke, 2012). Canning and Callan stated that when they implemented a heutagogical approach, learners displayed evidence of competence through reflection, self-awareness, ability to articulate feelings and ideas, participation in group discussions, investigation of ideas, and self-confidence (2010). Educators' unfamiliarity with andragogical and heutagogical approaches may be problematic when considering how to best address the needs of the adult learner.

Some post-secondary biology educators have a strong disciplinary background but lack the skills to teach that knowledge to others effectively (Bass, 2012). Typically, educators' teaching methods concentrate on their personal idea of what is appropriate without verifying whether their methods are supported by research (Minter, 2011). Educators of adults should allow the learner as much control as possible in his own learning process (Merriam, Caffarella, & Bumgartner, 2007). Practical application of theories that are suitable for adult learners could revolutionize post-secondary science education (Bass, 2012). These theories include self-directed, experiential, and transformative learning.

Self-directed learning requires development of the ability to manage and plan learning (Merriam, 2001; Merriam et al., 2007). Self-directed learning can lead to transformational learning (Blaschke, 2012). Transformational learning involves reflecting on life experiences and relating those reflections to previous perceptions, beliefs or attitudes, which can alter the learner's perspective (Mezirow, 1997). Transformational learning is especially pertinent to adults because they enter into educational experiences with significant prior knowledge (Bass, 2012). Experiences must be critically evaluated to lead to transformational learning (Bass, 2012). If educators emphasize the experiences of learners in positive ways, those experiences may become valuable resources for everyone in the class (Knowles, 1984). Experiential learning requires learners to make connections between what they have learned to prior knowledge, and envision future significance (Merriam et al., 2007). Critical reflection is also necessary for experiential learning to take place, and it allows advancement from andragogy to heutagogy (Bass, 2012). By underscoring the benefits of reflection, the role of the adult educator becomes important for the appropriate progression of learning processes to take place.

STEM interest and motivation. Science courses need to be more prospective and less retrospective in order to foster student interest (Osborne, Simon, & Collins, 2003). This may be accomplished by making topics relatable to students' past experiences and career goals rather than just recounting facts to be memorized. One study showed that 83% of adult learners stated their reason for wanting to learn was due to a change in their life, with 56% stating that career change was the reason (Aslanian & Brickell, 1980). Another study showed a strong relationship between three affective variables – attitude towards science, motivation to achieve, and self-concept – and an individual's achievement in science (Oliver & Simpson, 1988). This relationship is important to explore since motivation may increase simultaneously with increased confidence in one's own abilities. If motivation increases and a student develops a better attitude towards science, she may be more likely to pursue a STEM career.

Extrinsic motivation is generally defined as performance of an activity as a means to an end (Pintrich & Schunk, 1996), whereas *intrinsic motivation* is defined as doing an activity for the sake of performing it without an apparent reward (Deci, 1972). The constructs of *arousal, anxiety, interest*, and *curiosity* are those from which intrinsic motivation is derived (Koballa & Glynn, 2007). Interest is often the primary reason a student will give for success or failure (Vispoel & Austin, 1995). Interest is a construct of motivation and is the major link between the theoretical framework and the research design for this study.

Motivation has been studied extensively in science education research, and this study will focus on ways in which student interest is manifested while studying science in community college. There are four conditions that when met often result in students becoming and remaining motivated; this is the *ARCS Model* (Keller, 1987). The four factors related to motivation and interest are: attention, relevance, confidence, and satisfaction. Attention is a component of motivation and a requirement for learning (Keller, 1987). Attention is essential for the student to be directed towards "appropriate stimuli" and that direction must be sustained through the instructional period (Keller, 1987, p. 3). Relevance involves relating instruction to present or future career goals (Keller, 1987). Confidence is described as "expectancy for success" that can be attributed to abilities and effort, which can lead to persistence and accomplishment (Keller, 1987, p. 5). Confidence has also been defined as effort and ability as causes for success, rather than referring to difficulty of the task or luck (Dweck, 1986; Weiner, 1974). Satisfaction is when students "feel good about their accomplishments," and they are more likely to be motivated if the task and reward are defined and they have some sense of control in the learning process (Keller, 1987, p. 6). There is a relationship between the four assumptions of Adult Learning Theory and the four constructs of STEM interest: attention, confidence, satisfaction, and relevance. The relationship is summarized and pertinent interrelationships among these variables are represented in Figure 1.

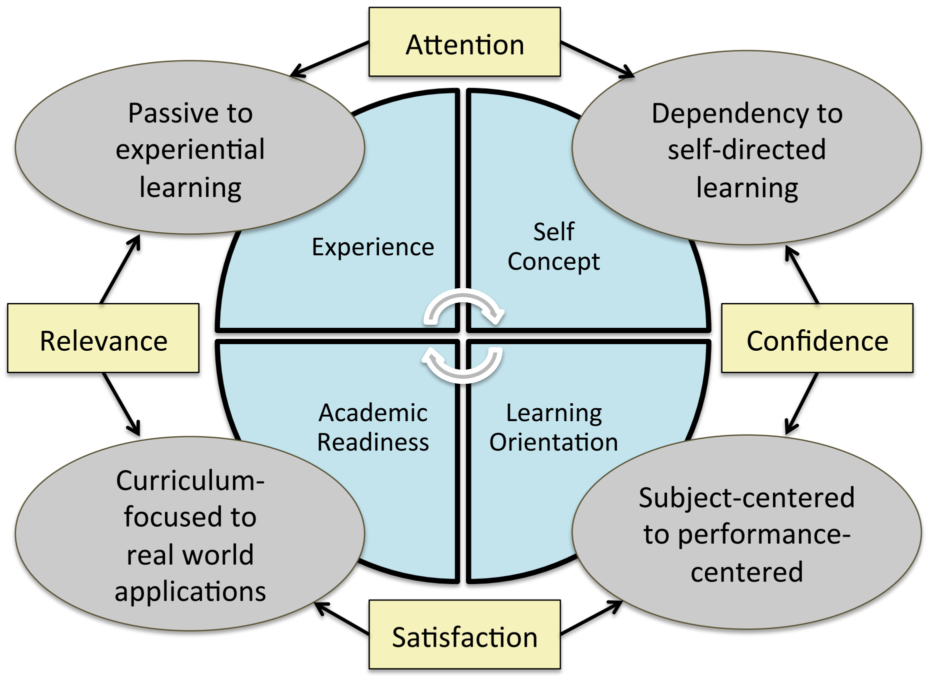


Figure 1. Adult Learning Theory applied to course interest factors.

The four assumptions of Adult Learning Theory are the basis for exploring students' attitudes towards STEM, the main goal of this research. The assumptions are defined in more detail below, along with the components of motivation and interest that have been shown to influence their decisions to pursue STEM (Keller, 1987). Examples are given to illustrate how these constructs may be manifested in the experiences of community college students.

Self concept of the learner. This assumption states that adults need to be self-directing and that the teacher should encourage this movement from dependency to self-directed learning.

- Confidence can be affected by previous experiences having made the learner feel "not smart." This method of facilitating active involvement and promoting self-directedness of learning can help to build confidence and promote a positive self-concept.
- The teacher serves as a guide and resource to gain and maintain the learner's attention.

The role of experience. Adults come to the educational setting rich with life experiences. Learning from experience tends to be more meaningful (for the learner as well as their classmates) than acquiring knowledge passively.

- Relevance to the learner's needs is reinforced when the lesson is tied to life experiences. Adults have more experience and can be valuable resources to others in the class. Since adults tend to have fixed habits and tend to be less open-minded, observing relevance in relating the material to their educational needs is very important.
- Attention of the learner is retained and strengthened by relating old experiences to new material and new experiential learning.

Readiness to learn. Adults need to learn about things that will provide them with tools for solving problems in their lives. The educator should be moving away from teaching a standardized curriculum and move more towards applications to life.

- Relevance is made obvious in the immediacy of application of problem solving tools because adults have a different perspective on life, work, and education than children and therefore view learning differently.
- Satisfaction comes from having learned how to solve problems that the learner experiences in his everyday life.

Orientation to learning. Adults need what they are learning to help them achieve their potential. The learner wants to be able to perform tasks and gain skills that will contribute to increased competency and therefore a better life. The educator should make learning less content-driven and more performance-centered.

- Confidence will increase as adults grow and social roles change due to their educational experiences (i.e. as they are promoted through positions at work). STEM success may lead to more social and economic mobility.
- Satisfaction comes from improving the learner's ability to cope with problems in her life through her education, and perhaps even improve her quality of life through being more qualified for a better paying job.

Along with the factors described above, this research will elucidate how various demographic, background and previous educational experiences might influence a student's motivation to study science and chose a STEM-related career. As Osborne et al. (2003) pointed out:

> Fundamentally, attitude cannot be separated from its context and the underlying body of influences that determine its real significance. In the case of school science, this points to the need to move away from general quantitative measures of attitude constructs and, instead, to explore the specific issue of students' attitudes to *school science*, and their

attitude to studying further courses in science *in school*, with a view to gaining information of their effect on student subject choice (p. 1055).

The current study investigated the body of influences in the students' life that affects his attitude. This will be discussed in the next section – how attitudes influence motivation, and how motivation affects learning and behavior.

2.5 Attitude and Motivation Research in Science Education

Attitude research in science education dates to 1917 with John Dewey emphasizing that acquiring scientific attitudes is essential in the education of reflective thinkers (Koballa & Glynn, 2007). Attitude and behaviorial studies done during the early to middle 20th century had a major influence on science attitude research (Koballa & Glynn, 2007). In 1928, Thurstone determined that attitude could be measured (Thurstone, 1928), and four years later Likert developed a technique for measuring attitude that is still commonly used today (Likert, 1932). Later, a relationship between attitude and behavior was described by Sherif, Sherif, and Nebergall (1965). Their model, *Social Judgment Theory*, states that the ability to change an individual's attitude is related to their degree of involvement when listening to a persuasive message about that topic, the importance of the topic to them, and the subsequent judgment they make (Sherif et al., 1965).

A shift in research came in the 1970s when substantial emphasis on students' attitude towards science was the area of more concern (Koballa & Glynn, 2007; Osborne et al., 2003). This increase in attitudinal research was due in part to evidence revealing decreased interest and pursuit of science-based careers (Department for Education, 1994; Smithers & Robinson, 1988), and in part due to research showing a large portion of the general population lacked scientific literacy (Durant & Bauer, 1997; Durant, Evans, & Thomas, 1989; Miller, Pardo, & Niwa, 1997). This led the field of research more towards behavior and away from attitude, as Ajzen and Fishbein's *Theory of Reasoned Action* (1980) stated that one's intentions determined his behavior, and therefore focused on attitude predicting behavior.

Emphasis on attitude in science education research decreased in the 1990s, in part because many findings had offered no solutions to increase teacher or student performance, nor had they advanced the field of research (Koballa & Glynn, 2007). For example, some studies stated that activity-based instruction showed positive effects in students' attitudes towards science, whereas other studies presented conflicting results (Simpson, Koballa, Oliver, & Crawley, 1994). Additionally, paradigms in research of social and educational psychology that affected attitude research in science education shifted to more cognitive studies rather than behavioral studies (Osborne et al., 2003; Richardson, 1996). However, after the turn of the 21st century, research in students' science related attitudes was revived due to major decreases in enrollment in science courses at the secondary and post-secondary levels, especially in Western nations (Osborne et al., 2003). Given that attitudes and motivation have both influenced entry into the study of science and respective outcomes, they are both important constructs (Bloom, 1976; Kremer & Walberg, 1981).

Terminology in attitudinal and motivational research. The terminology used by researchers involved in attitudinal and motivational research is not consistently defined and is sometimes ambiguous. For instance, terms such as: *interest, value, motivation*, and *opinion* are often erroneously equated to attitude (Koballa & Glynn, 2007). Attitude is defined as "a general and enduring positive or negative feeling about some person, object, or issue" (Petty & Cacioppo, 1981, p. 7), while “motivation is an internal state that arouses, directs, and sustains students’ behavior” (Koballa & Glynn, 2007, p. 85).

Causal relationships exist in that attitude influences motivation, and motivation affects learning and behavior. These relationships are important in understanding how attitude, motivation and behavior are related to one another. The *Theory of Reasoned Action* states there is a causal relationship between attitude, belief, and behavior (Ajzen & Fishbein, 1980). Whereas attitude toward the behavior (AB) refers to the overall evaluation of a particular behavior, and is the *affective* component of the model, it is also a major determinant for behavioral intention (BI), which is the *conative* component. The individual’s personal beliefs are developed by cognitive skills that formulate attitude (Crawley & Black, 1992). It is important to note that *attitude* is distinctly different than *values*, which are broader, more complex and enduring in comparison to attitude (Trenholm, 1989); *beliefs*, or cognitive basis for an attitude (Ajzen & Fishbein, 1980); and *opinions* - attitude expressed verbally (Shirgley, Koballa, & Simpson, 1988).

To examine the four orientations of motivation, many researchers studied their subjects with more than one orientation, which resulted in a mixture or hybridization. *Behavioral orientation* inspects incentive and reinforcement of behavior. The problem with incentives may be that they deter development of *intrinsic motivation* within the student. The *humanistic orientation* focuses on an individuals’ capacity for personal growth, deciding their own destiny, and desire to do well. Koballa & Glynn (2007) summarized several researchers’ definition of the *cognitive orientation* as exploring motivation from students’ goals, plans, expectations, and attributions, which explains their behavior (Weiner, 1992). *Social orientation* concentrates on how a student self-identifies and views relationships with others in academic and out-of-school communities (Koballa & Glynn, 2007).

Interest as a construct of motivation. Before examining the various factors that affect motivation, the difference between intrinsic and extrinsic motivation will be delineated. Extrinsic motivation is generally defined as performance of an activity as a means to an end (Pintrich & Schunk, 1996), whereas intrinsic motivation is defined as doing an activity for the sake of performing it without an apparent reward (Deci, 1972). Academic motivation is a multidimensional construct, and career outcome expectations can have a variety of effects on motivation (Domene, Socholotiuk, & Woitowicz, 2011). *Interest, arousal, anxiety*, and *curiosity* constructs are those from which intrinsic motivation is derived (Deci, 1972). At the college level, non-majors have been more intrinsically motivated to study science when they found it personally relevant (Glynn, Taasoobshirazi, & Brickman, 2009). There has been a lack of focus on relevant factors relating to *interest* in and entrance into STEM, which could be critical in addressing the leaky STEM pipeline (Wang, 2013). It is also important to consider whether a student interested in STEM left for reasons related to the way the sciences were taught or because the student found a better match for her interests and abilities (NAS, 2016).

Interest is a construct that has not been well studied but is of great importance to science education research. One study found the instructor’s approach to teaching was of major significance in developing student interest in science. The teacher’s interest was easily passed to the student, inspiring students on a cognitive and emotional basis (Szlarski, 2011). These students preferred variation in the classroom and working procedures that required activity, such as discussion or role-playing. Abstract challenges have also been shown to stimulate students’ interest and enthusiasm for science (Woolnough, 1994). One study suggested that career outcome expectations and type of aspiration were crucial links in understanding post-secondary students' intrinsic and extrinsic motivation. Informing students of career choices, particularly in STEM, has benefited student motivation in STEM coursework (Domene et al., 2011). In order to increase student motivation to study science and enroll in STEM-related careers, investigating and identifying psychological factors that change and influence student interest in science are essential.

Lack of confidence often hinders student interest in science and, therefore, motivation, engagement, and enrollment in STEM-related courses and careers. Osborne and Collins (2000) found that relevance affected attitude when comparing students studying biological and physical sciences. Ebenezer and Zoller (1993) found that 71% of secondary students found science interesting, though they dropped it, and 79% enjoyed the practical portion of the class that helped them understand topics relevant to their lives. Enjoyment, relevance, and authenticity are recurrent themes when researching interest and motivation to study science.

Motivation related to gender and student interest of pre-college students. In order to explore background factors that affect the choice to pursue science-based careers, it is necessary to examine pre-college factors that affect interest in science. Kahle and Lakes (1983) stated: "lack of experiences *in* science leads to lack of understanding *of* science and contributes to negative attitudes *to* science" (p. 135). Similarly, a study by Johnson (1987) revealed that when differences between boys' and girls' interests occurred early in life, parallel differences in their science performance occurred. Likewise, a lack of technology "tinkering" for girls due to culture, as well as girls' own negative perception of their abilities in science, may have contributed to driving girls towards other subjects (Osborne et al., 2003). Experiences in science at an early age are crucial for development of interest.

It is important to note that females have been on par with or scored above their male counterparts in science achievement at an early age. Gender stereotypes can be mitigated by encouraging girls to become engaged in science early in order to enter the pipeline. Girls may develop more interest in technology and science by encouragement from educators with more progressive teaching styles (Lightbody & Durndell, 1996; Lightbody, Siann, Stocks, & Walsh, 1996).

Academic enjoyment and student interest. Technology and gaming can be fun and therefore can lead to interest in science. "Fun" was the most used term in qualitative responses in a study where students learned about the solar system and economics through computer games (Lui, Horton, Olmanson, & Toprac, 2011). The experience was positive and highly taxing at the same time, demonstrating that hard work can lead to increased learning. The students also appreciated the freedom to work on tasks at their own pace (Lui et al., 2011). The students were motivated not only because of the task being fun but because they had control over the learning process in problem solving activities.

Fun was also an important criterion for learning motivation in Szlarski's study of teenage high school students (2011). The results of the work by Lui et al. (2011) confirmed this relationship between motivation and high post-test scores in a middle school problem-based learning study. The rich, media based presentation helped with acquisition of knowledge. The role of being a scientist, problem solving and dealing with a challenge in a multisensory environment was engaging and sparked curiosity in the students (Lui et al., 2011). While not all learning can be fun, the engagement that such an activity can provide may generate a life long interest in science.

Learning progress and student interest. It can be difficult to attract adolescents to a science topic and engage them in learning. A small Swedish study provided insight as to what motivated young adults to study science in school. Focus groups revealed that "interest" and "progress" were identified as the most invariant responses, and therefore, essential experiences of students when studying biology, physics and mathematics (Szlarski, 2011). Progress is essential to motivation – if a student is successful but does not see potential for deepening his knowledge, he may lose his drive. These students suggested that teachers should stimulate their students by using indicators that the students are making progress (Szlarski, 2011). These students also mentioned that schools should avoid unchallenging reproduction of knowledge, because this type of cognitive goal is of lower range than the understanding approach (Szlarski, 2011). Learner self-esteem can be increased by the educator's acknowledgment of student contributions, which can help motivate and lead to success (Blondy, 2007).

Fixed and growth mindsets. Research regarding the patterns of how cognition affects behavior has been important to the study of motivation related to mindset (Dweck & Leggett, 1988). Two major patterns of academic behavior were identified in a student's approach to challenging tasks: 1) adaptive or mastery-oriented response, and 2) the maladaptive or helpless response (Diener & Dweck, 1978, 1980; Dweck, 1975; Dweck & Reppucci, 1973). Differentiation between the different types of goals that individuals pursue might help to understand an individual's pattern of response (Dweck & Elliott, 1983). The classes of goals for intellectual achievement were identified as performance goals, or those which purpose is to gain judgment, and learning goals, which serve to increase competence (Dweck & Leggett, 1988). Several studies have shown that a performance goal orientation is more susceptible to a helpless response pattern while a learning goal promoted a mastery-oriented pattern of response (Elliott & Dweck, 1988).

Individuals may perceive intelligence is a fixed trait and that they have a certain amount that is not changeable. This is called "entity theory" of intelligence due to an individual's belief that her intelligence cannot change (Dweck & Leggett, 1988). This conception was associated with adoption of a performance goal. Conversely, individuals who perceived their intelligence was malleable would associate with learning goals (Leggett, 1985). When individuals believe they have intelligence that can be increased with effort, they possess an "incremental theory" of intelligence (Dweck & Leggett, 1988).

Dweck and Leggett (1988) described these two theories of intelligence and how they relate to an individual's goal orientation, perceived ability, and pattern of behavior. Individuals who are entity theory oriented, or perceive intelligence as fixed, have performance goals. With regard to entity theory, how the individual perceives her ability or intelligence level will dictate her behavior patterns. Those who perceive low ability express the helpless patterns of response, meaning they will avoid challenges and are less likely to persist. Those who perceive their abilities as high will have mastery-oriented patterns of response and will tend to seek challenges and persist. Individuals that are incremental theory oriented believe that intelligence is malleable and they tend to have learning goals. In this theory, whether the individual's perception of his own ability is high or low, he displays mastery-oriented behavior. These individuals realize that rising to a challenge can lead to learning and these individuals tend to persist (Dweck & Leggett, 1988). Depending upon the way an individual characterizes his own intelligence, that is, entity or incremental, will determine what type of goals he sets and these are a function of his self-concept (Dweck & Leggett, 1988).

Goals and student interest. Goals are related to performance and a student's self-concept in identifying as a "science person." In a science classroom setting where students learned about natural selection, pre-, post-, and delayed post-tests were administered to study transfer and conceptual change (Pugh, Linnenbrink-Garcia, Koskey, Stewart, & Manzey, 2010). Achievement goal orientations and science identity were measured during a pre-test, and two common misconceptions were assessed, relating to natural selection and inheritance. Achievement goal orientation was viewed through a three-factor cognition model: master, performance-approach, and performance-avoidance. Transformative experience was positively correlated with post-test and follow-ups; those students that had higher levels of transformative experience also learned the information with greater depth (Pugh et al., 2010). Mastery goal orientation possibly mediated the relationship between science identity and transformative experience. The results indicated a student did not need to see herself as a "science person" to be good at science, rather, if she were intrinsically motivated she could learn the subject material. Experiences early in life, enjoyment of the subject, a sense of making progress, and goals are all related to increasing motivation to study science (Pugh et al., 2010).

Science identity (whether the student identifies himself as a "science person" or not) was explored with the 9th and 10th graders from a Midwestern U.S. high school biology cohort. They were studied in order to investigate the transformative nature of science, goal orientation, science identity, and the causal relationships between them (Pugh et al., 2010). Science identity and mastery goal orientations, also sometimes referred to in science education research as "learning goal" or "task goal" (Koballa & Glynn, 2007), were positively associated with transformative experience; the more students identified with science and were driven to develop their competence in biology, the more likely they were to engage in learning the subject matter (Pugh et al., 2010).

2.6 Motivation to Attend College and Choosing to Study Science

Measuring traditional students' motivation to attend college was the subject of further study based on six previously known motives for entering college: career interest, financial security, intellectual curiosity, social opportunity, norms and family expectations, and self-discovery (Corts & Stoner, 2011). Results from one study suggested that new high school graduates choice of STEM-related careers was influenced by intent to major in STEM, which was influenced by achievement and experience in high school mathematics courses, as well as experiences in post-secondary education such as academic interactions and receiving financial aid college (Wang, 2013).

Bettinger (2010) stated that the making of a scientist begins quite early, in primary and secondary education, when one is acquiring skills and interest develops to pursue post-secondary science. According to Bettinger, there are two schools of thought on how students choose a major. One is Holland's theory (1966), which is based upon an institution's ability to create an environment that suits the student's personality. The other model, developed by Manski in 1993, is based upon human capital formation, which asserts that individuals are geared toward gaining skills that will assist in making them the most money yet not cost them excessive time or money to acquire (Bettinger, 2010). Note that interest in the subject matter was not a factor in either of these two theories.

Motivation to study science during college has been affected by a number of factors, mainly support systems, peer-interactions, learning and immersion, self-efficacy and self-regulatory practices, perceived relevance to future career, and expectations about what is required to succeed in science courses. Corts and Stoner (2011) surveyed 119 voluntary undergraduates aged 18-24 from community colleges, liberal arts colleges and universities. The subjects completed online surveys including the *College Motives Scale* (CMS), *Learning or Grade Orientation* (LOGO) and demographic information in order to explore relationships between motives to attend college and students' courses of study. Career and social motives positively correlated with grade orientation, or the desire to achieve good grades or perform well. Intellectual and self-discovery motives positively correlated to learning orientation. Self-discovery, or addressing "existential and moral questions" (Corts & Stoner, 2011, p. 777), ranked higher with liberal arts students compared to the community college and the research universities' students (Corts & Stoner, 2011). Community college students rated intellectual curiosity the highest followed by career and financial as motives for attending (Corts & Stoner, 2011), suggesting that the average community college student has a specific major or area of interest in mind when she enrolls.

STEM motivation and biology majors. One study was conducted to observe whether biology majors and non-majors differed in motivation, study time, interest, and achievement in courses that had the same five-semester learning goals (Knight & Smith, 2010). At the University of Colorado, 72 non-majors and 151 majors were surveyed three times throughout the semester and completed pre-course and post-course assessments. Each of the courses met three times a week for 50 minutes and utilized similar instructional approaches. Majors and non-majors had similar incorrect conceptions upon entering the course about certain genetics concepts. The biology majors began the semester with higher motivation and interest in the subject, reported more study time, engaged more in group work, tended to have more expert beliefs about studying, and saw a stronger connection between the course work and their future careers. Non-majors were less interested in genetics, saw low relevance of genetics to their careers, and lacked motivation to study it (Knight & Smith, 2010).

Other researchers have found non-majors were intrinsically motivated to study science when they found it personally relevant (Glynn et al., 2009). From three biology courses for non-majors, 770 undergraduates were surveyed. Non-science majors classified their motivation to learn science in terms of five dimensions: intrinsic motivation and personal relevance, self-efficacy and assessment anxiety, self-determination, career motivation, and grade motivation. When students had high self-efficacy and were confident, they had low assessment anxiety. Grade motivation included items from the other extrinsic motivation component, such as wanting to do well and competition with other students (Glynn et al., 2009). Perceived relevance to a career proved to be an important factor in motivation and engagement. Non-majors also expressed less intimidation by the subject matter in comparison to the majors, which led to lesser study time; this reinforced the idea that confidence is related to performance (Knight & Smith, 2010). Although grades are important, this study and others have shown that intellectual curiosity, career and financial motives, and relevance are very important in attending college and learning science.

2.7 Gender and STEM Motivation

Although women are the majority of the population in the U.S., as well as the majority of college students, they are still an underrepresented population in post-secondary science (Starobin & Laanan, 2008). Women who started at community colleges had a higher completion rate than men - 42.6% compared to 36.5%, respectively (Juszkiewicz, 2015). Women's social orientations are important in understanding their motivations, or lack thereof, to study science.

Women have been more likely to pursue STEM degrees when receiving encouragement from family, friends, faculty, and counselors than without the help of individuals who validated their choices (Richman & Van Dellen, 2011). Overcoming misconceptions and stereotypes is important for increasing the number of women in science. For example, in one study, female students expressed that they wished they knew earlier that it was possible for them to study engineering, and that the stereotype that men are better in mathematics and women are better in humanities is not necessarily true (Starobin & Laanan, 2008; Stewart & Osborn, 1998). Females interviewed in this particular study also felt that proper advising was crucial to their success at the community college. Diverse populations, cultures, and lifestyles that exist at community colleges may have allowed female students to focus on their education and not their gender, encouraging confidence and self-esteem (Starobin & Laanan, 2008). This study also mentioned the need for community colleges to partner with K-12 schools to promote girls' interest in pursuing STEM studies at an earlier age, in addition to having articulation agreements for transfer to four-year institutions.

In an 18-month longitudinal study, females enrolled in science at a Canadian university were observed to evaluate the relationship between gender stereotype endorsement and autonomous academic motivation (Delisle, Guay, Senecal, & Larose, 2009). *Gender stereotype endorsement* refers to the idea that males are better at science than females and endorsement of that idea has led to fewer females enrolling in sciences (Delisle et al., 2009). The study suggested that the more women were exposed to low numbers of female peers in science programs, the more likely they were to endorse the idea that science is a domain for males. The study also suggested that autonomy-supportive practices are important factors to investigate further. These results concurred with other studies that suggested that the way to reduce gender stereotype issues and their negative consequences might be to attract more female instructors to science (Delisle et al., 2009; Koul, Lerdpornkulat, & Chantra, 2011; Rask & Bailey, 2002).

A study of Chinese college students showed that gender did not affect students' motivation to study science (Yingqui & Gauvain, 2012), and the same results came from two studies of American non-science majors by Glynn et al. in 2007 and 2009; however, females in a biology course for non-majors had more self-determination (a humanistic orientation) than the males (Glynn et al., 2009). Conversely, a study of non-majors enrolled in an entomology course showed gender-based differences in learning preferences and motivation to study content (Jones, Antonenkot, & Greenwood, 2012).

Motivation and non-traditional female students. There is a relatively large non-traditional female college student population at most community colleges. Women with children who returned to get an education had many factors related to their motivation to return to school, such as previous education, age, marital and family status, satisfaction with employment, and personal support systems. Motivation might not be lacking in those that did not graduate, but rather, life situations and conditions that interrupted their ability to finish their education (Scott, Burns, & Cooney, 1998). Women in difficult personal situations often showed high motivation to complete their degrees and improve their lives; however, these difficult circumstances were the very things that may have impeded their goals (Scott et al., 1998). When it comes to gender differences and motivation in science education, more research is necessary to examine the unique circumstances women experience.

2.8 Effect of Teacher Influence on Motivation

Past research has not reached consensus regarding how teachers affect motivation. The teacher's approach to the material may affect the student's interest and teacher interest may be transferred to the student (Szlarski, 2011). When teachers lack confidence and familiarity with the subject matter, teaching quality and learning are compromised (Osborne et al., 2003). It has been shown that teacher subject knowledge is required for effective teaching (Dillon, Osborne, Fairbrother & Kurina, 2000; Osborne & Simon, 1996; Shulman, 1986; Tobin & Fraser, 1988; Turner-Bisset, 1999). This has ramifications for the teacher's pivotal role in student interest and motivation.

Studies have shown that a variety of teaching styles are vital to sparking student interest in science prior to college (Myers & Fouts, 1992; Pilburn & Baker, 1993). Elements of the classroom environment can also influence attitude (Haladyna, Olsen & Shaughnessy, 1982; Simpson & Oliver, 1990; Talton and Simpson, 1987; Woolnough, 1991). While Myers and Fouts (1992) found that positive attitudes correlated with high levels of involvement, personal support, good relationships with classmates, unique learning tasks, and various teaching strategies (1992), Woolnough found that the strongest two factors in students opting for science and having a positive educational experience were quality of science teaching and participation in extracurricular activities (1991). The teacher is a significant factor in student attitude towards science (McMillan & May, 1979; Pilburn & Baker, 1993; Sundberg, Dini & Li, 1994; Woolnough, 1991), and for liking or disliking a subject (Hendley, Parkinson, Stables, & Tanner, 1995). Knowles found that instructors need to care about the actual interests of their students rather than their own perceptions of what the students' interests should be (1984).

2.9 Teacher Preparation and How Students Learn

Since teachers have the ability to influence student interest in science at an early age, teacher preparation is an important aspect to consider when examining the experiences of community college students. Students arrive in the classroom with preconceptions about the world around them and it is essential for an effective teacher to build upon preexisting ideas (Donovan, Bransford, & Pellegrino, 1999). As stated by a report from the National Research Council (Donovan, Bransford, & Pelligrino, 1999), effective science teachers will "1) have a deep foundation of factual knowledge, 2) understand facts and ideas in the context of the conceptual framework, and 3) organize knowledge in ways that facilitate retrieval and application" (p. 12). Immersion into learning through real life situations is how the brain learns best and fragmenting concepts can take the joy out of learning (Bransford, Brown, & Cocking, 1999; Jensen, 1996). As more connections are made, the greater the probability that students can form high-level inferences. However, most teachers do not teach in a way that facilitates learning concepts globally rather than in pieces, especially if the teacher has weak pedagogical content knowledge (Shulman, 1986).

2.10 Reasons for Attrition in STEM

Lack of preparation for STEM college course taking can factor into changing majors. American College Testing (ACT, 2010) stated that students significantly lacked in science and mathematics coursework in high school and they estimated in 2010 that only 29% of students were prepared for college level sciences. For those that were seen as adequately prepared for college, four possible reasons have been cited for not persisting: 1) lacking initial interest in STEM, 2) straying from STEM and finding difficulty in getting back on track, 3) the higher education STEM culture may be off-putting, and 4) students feel that they can make more money in other fields (Bettinger, 2010). Despite increases in the number of women faculty, they are still less than 25% of all science, engineering and health instructors (NSF, 2011). Female students in STEM may have subconsciously received a message that perhaps women do not belong in the field.

Interestingly, those who switched from a STEM major early in their education were just as likely to do well in their STEM courses, so difficulty was not a deciding factor (NRC, 2012). Defection from STEM was high even amongst the top achievers (Bettinger, 2010), so factors other than ability were at play. An estimated 30% of students change their major during the first year of college (Saenz & Barrera, 2007). During that academic year, students expressed a sense of decreased mathematical ability, decreased "drive to achieve," and less perceived academic ability. Consequently, they often moved towards majors that involved less mathematics and were less competitive (Bettinger, 2010). Urging students to prioritize might help them develop an interest and passion for science that cannot be easily swayed by peers or other environmental influences in the first year of college.

Some students may change from STEM majors for financial reasons, as 81% of incoming freshman in 2012 stated that becoming "very well off financially" was an important goal of theirs, while only 54% said that in 1966 (Pryor et al., 2012). During that same time frame, salaries of non-STEM careers have increased more quickly than STEM salaries (Bettinger, 2010). Perhaps this is why 48.7% of STEM changers switched to business, 21.2% changed to social science, and 11.1% changed to education (Chen & Weko, 2009). Community colleges are uniquely positioned for contextual studies on changes in major, changes of interest in subjects, and motivation to study science.

2.11 STEM Major Demographics

The demographics of STEM majors reveal disparities among underrepresented groups. Female enrollment (14%) was less half of male enrollment (33%) in STEM in 2006 (Chen & Weko, 2009). Since Asians comprise a large percentage of STEM degree students, graduates and functioning STEM professionals, they are not considered to be underrepresented minorities; rather, women, persons with disabilities, Black, Hispanic, and American Indians are considered to be underrepresented minorities (NSF, 2011). Immediate college enrollment of White and Asian students was higher than Black and Hispanic enrollment in 2009 (NCES, 2011), and these groups had higher bachelor degree attainment than Blacks and Hispanics (Chen & Weko, 2009). However, Black students were less likely to leave bachelor STEM programs than other students, (NRC, 2012). Women and older students were more likely to leave; even high achieving women were likely to leave STEM majors for what they perceived as more lucrative careers (Bettinger, 2010).

2.12 Achievement and Persistence in STEM

From 1995-96 to 2003-04, college students of all ages majoring in STEM dropped by 9% (Chen & Weko, 2009). Entrance into STEM fields was higher among students that took trigonometry, pre-calculus or calculus. They also had a GPA of B or higher, were in the top 25% of scorers on college entrance exams, and were more likely to attain graduate degrees than their counterparts not taking higher-level mathematics in high school (Chen & Weko, 2009). STEM major retention was highest among high mathematics achievers (Bettinger, 2010).

STEM majors had better outcomes than non-STEM majors with 6-8% higher bachelor degree completion rates, and they were 6-9% less likely to leave college without a degree of any kind. Of those that entered STEM between 1995 and 2001, 41% earned a STEM degree or certificate, 12% were still enrolled, but 21% switched to non-STEM and 27% dropped out of postsecondary education all together. Interestingly, 7% of non-STEM and 16% of undeclared majors became STEM majors. Regarding those that changed their majors, 24% of math and 28% of physical science majors switched to another STEM discipline and most students earned a bachelor's degree in the STEM field that they initially chose (Chen & Weko, 2009).

Strategies for improving STEM retention for community college students. When students enrolled in science courses and were focused and interested, they were more likely to stay in STEM. When 60% of the student's first semester courses were STEM-related, that student was more likely to stay in STEM (Bettinger, 2010). NAS (2016) stated that students interested in STEM should be enabled to make informed decisions regarding STEM choice, given the opportunity to pursue the degree with minimal obstacles, and be supported by faculty, advisors, and mentors rather than feeling pushed away. Brooklyn Gateway sought to immerse students taking freshman level general chemistry in a six-week immersion sessions and actually found that students' class averages were repeatedly higher than the regular six-week and 12-week counterparts. Though accelerated, students had greater ability to focus when enrolled in fewer courses (Lloyd & Eckhardt, 2010). These six-week immersion sections required students to attend four hours per week of peer-led team learning, and daily access to drop-in tutors was available for this particular cohort. With this extra support, the students achieved better grades than their counterparts, however, they realized these science courses were time consuming and challenging (Lloyd & Eckhardt, 2010).

Similarly, immersed students did better in organic chemistry in comparison to their twelve-week counterparts (Lloyd & Eckhardt, 2010). Organic chemistry, which is typically conceived as more difficult than general chemistry, has considerable conceptual overlap but the pedagogies for teaching each course are quite different. This study also mentioned that failure rates for organic chemistry were significantly lower than in general chemistry at this institution, perhaps due to their creating a mechanism for study where students' success in general chemistry would contribute to their success in advanced science courses (Lloyd & Eckhardt, 2010).

Self-regulation and STEM retention. A study of English Language Learners in STEM disciplines reported the subjects benefited from integrated learning communities in a geoscience course. This strategy assisted them in future science courses due to improved adaptation and self-regulation, which involve confidence, cognition, and metacognition (Fayon, Goff, & Duranczyk, 2010). Peer-led assistance and learning communities proved to be beneficial for their academic performance. Student learning is often based upon motivation and developing self-regulatory strategies, such as goal setting, time management, effective use of resources, monitoring performance, creating a productive work environment, and pride in one's own efforts (Maurer, 2003). Community college instructors should make it a priority to promote self-regulation in academic tasks.

Self-regulatory mechanisms were also shown to help increase motivation. In one study, a molecular biology class of 94 students was investigated to elucidate what affected learning paths and strategies (Van Seters, Ossevoort, Tramper, & Goedhart, 2012). The subjects were heterogeneous, comprised of 12 different nationalities, some undergraduate and some graduate. The study utilized adaptive e-learning material after lecture. Learning path in this study referred to the average step size, number of attempts and number of exercises required to complete the adaptive e-learning materials. Prior knowledge was examined by pre-test, and a post-test questionnaire surveyed their intrinsic motivation and demographics. Prior knowledge did not affect students' individual learning paths; however, intrinsic motivation was found to have an influence. Highly motivated students chose smaller steps and took more time with each step, but needed less attempts to complete the exercises. Highly motivated students used information sources that were available more often than less motivated students (Van Seters et al., 2012). The data suggested that e-adaptive learning can be an effective tool, especially for personalized learning in heterogeneous populations. Further investigation of the impact of self-regulated learning strategies and feedback on student motivation and achievement is warranted.

Self-determination theory and STEM performance. One study employed self-determination theory to investigate whether instructor-supported autonomy (e.g., encouraging the student to solve a problem in their style) increased student performance in a college level organic chemistry course, as opposed to an instructor who used controlling pressures (using rewards or punishments). In this study, *self-determination theory* was described as how interpersonal relationships could influence an individual in the two aforementioned ways. Autonomy-supportive situations tended to reinforce or increase intrinsic motivation and conversely controlled regulation demoted intrinsic motivation (Black & Deci, 2000).

Students who initially enrolled in this organic chemistry course for autonomous reasons showed higher perceived competence, as well as interest and enjoyment of the course. These students also expressed lower anxiety, had performance goals that focused on their grades, and tended to stay in the course, making adjustments throughout the semester to succeed. When these students felt that their instructor was supportive of their autonomous style, autonomous self-regulation tended to increase (Black & Deci, 2000). Learners may desire a more self-directed learning environment but require guidance and encouragement (Cheren, 1983). Students whose autonomy increased during the semester did increase performance and received better grades. Student autonomy was better supported by an inquiry-based style of learning rather than typical lecture style teaching (Black & Deci, 2000). When students immerse themselves in science studies, possess self-regulatory mechanisms, and are in autonomy supportive situations, they have a greater tendency to learn and persist in STEM.

2.13 College Readiness

Public views of science and scientists. The majority of Americans rated scientists as having "very great prestige," rating them second to only firefighters in this category (NSF, 2014). If Americans view scientists as individuals holding highly prestigious jobs, why are there far less STEM majors, especially now, when the job market predicts a greater need than ever for STEM professionals?

Recent information from the Pew Research Institute stated that there is a disparity in what American citizens think about science compared to American Association for the Advancement of Science (AAAS) scientists. The majority of the scientists (84%) viewed the public's lack of science knowledge to be a major problem and they attributed this to several factors (Funk & Rainie, 2015). Data revealed that 75% of these scientists believed that not enough K-12 STEM education was a major contributing factor; 57% felt that lack of public interest in science news was a major factor; and 43% said that lack of media interest in science was a major factor in this problem. The public and the AAAS scientists alike felt that there were problems in K-12 STEM education with 46% of the scientists and 29% American citizens characterizing it as below average. Lack of interest and issues with science education are common threads in what scientists and the public perceive as problematic (Funk & Rainie, 2015).

Science literacy and science achievement in the U.S. In an NSF study from 2008, American students in grades 3-12 were ranked 12th in the world in science (NSF, 2010). In 2012, the United States ranked 17th in the world in the science, 25th in mathematics (Pearson Education, 2015b), and 17th overall in cognitive skills and educational attainment among developed nations (Pearson Education, 2013). The U.S. is now ranked 14th, but is still grouped in the same category of standard deviation; therefore, this is not a significant increase (Pearson Education, 2015a). The Program for International Student Assessment (PISA), which measures reading, mathematics and science literacy of 15-year-olds, stated that the U.S. placed 35th in math and 27th in science in a group of 63 countries (Organization for Economic Cooperation and Development [OECD], 2014). Most recently, the OECD ranked American 15-year olds 28th in science and mathematics, and one researcher projected that the U.S. Gross Domestic Product (GDP) could increase 153% if all 15-year olds achieved a basic level of education (OECD, 2015). The trend is that science achievement is worsening rather than improving. This is an important consideration when evaluating the role of community colleges in preparing students for science study and careers.

2.14 The Many Challenges that Community College Students Face

Academic factors. There are serious problems in this nation's college readiness as shown by high needs for developmental coursework at the college level. Community colleges enroll many students requiring developmental reading as well as mathematics courses before the students may move on to credit bearing courses; 42% of first year community college students required at least one remedial course in 2008 (NCES, 2011). This contributes to six-year graduation rates. Mathematics remediation courses are sometimes ineffective, which could have some bearing on low completion rates (NGA, 2011).

There are other obstacles. Some community college degree and certificate programs have not matched current and future employer needs, and it may be that students are not developing critical thinking, application and problem solving skills (NGA, 2011). STEM pathways have natural barriers in that some students feel discouraged by highly competitive environments in the science and mathematics "gatekeeper" courses, in particular woman and underrepresented groups (NAS, 2016). Some credits are not portable, so if part of a certificate program is completed those credits might not transfer anywhere else (NGA, 2011). Due to varying articulation agreements with four-year institutions, transfer can sometimes be difficult and time consuming (NGA, 2011). This can increase the cost of students' overall education, which can have negative effects on a student's likelihood to persist in STEM (NAS, 2016).

Shared authority in the classroom and positional advantage. Equity issues arise when all students are not afforded the same opportunities. Basu (2008) believed that "shared authority" and "agency" can help students to form their voice, which helps create opportunities for students, stating: "Sharing authority is an important feature of developing classrooms in a critical framework because when historical norms for power dynamics between teacher and student are challenged, marginalized groups can have greater voice in, access to, and success in school" (Basu, 2008, p. 883).

Agency has four main properties: intentionality, forethought, self-reactiveness and self-reflectiveness; these influence one's life circumstances and ability to function in those circumstances (Bandura, 2006). Bandura stated that it is important for one to realize that he is not just a product of circumstances but that he contributes to those circumstances (2006). When teachers promote agency it enables the student to envision changing her life situation (Basu, 2008). Part of that change is the belief that furthering her education can provide a positional advantage beyond her school years. This can be a powerful aspect of a student's preparation that leads her to community college.

In 2007, Unterhalter and Brighouse identified three important factors that benefit education through a social justice lens. These factors were that education can cause enhancement of quality of life, provide access to work opportunities, and affect a person's opportunities relative to others, or positional advantage (McCowan, 2010). Education should be a right for everyone but it is not always that simple, in part due to one's starting position (McCowan, 2010). McCowan believed that the definition of right to education should be expanded to also include the right for educational experience and the right to positional advantage (2010).

Pre-college and college guidance. Shultz, Metz, Lowes, McGrath, and McKay (2008) revealed that most guidance counselors hold misconceptions or suffer from a lack of information regarding STEM. The majority of guidance counselors that participated in their conference admitted that they needed to improve their STEM career advising (Shultz et al., 2008). Guidance counselors should be prepared to communicate future job opportunities for high school students. College level students across the board, whether in community colleges, technical colleges or four-year colleges, have often requested better and full-time advising (Lake Research Partners, 2011). Recruitment and retention in STEM disciplines may be strengthened with more rigorous guidance protocols in pre-college and college institutions.

Advisement from institution to institution varies greatly. For example, some students need permission to register while some enroll in courses that are not part of their degree program due to lack of available guidance. In a report prepared for the American Federation of Teachers by independent researchers, college students stated that they need help understanding program requirements and developing their goals and plans for the execution of coursework; these students cited lack of adequate academic guidance and advising as one of their four major obstacles to success (Lake Research Partners, 2011). Advising is often necessary for academic success and avoiding enrollment in unnecessary courses (NRC, 2012). When students had a community college faculty member mentoring them they showed increased commitment to their goals and intent to persist (Crisp, 2009). Community college persistence rates were increased when students received procedural assistance such as access to an academic advisor, as well as help with applying for financial aid and being made aware that they should ask for help when they need it (Deil-Amen, 2011). Community colleges should strengthen new student orientation programs and assign each student a dedicated advisor in the field of interest to help save time and money for the students. Other major obstacles to success have been lack of financial resources, sufficient time and balance between school and other responsibilities, and lacking "soft skills," such as study and time management skills, which directly affect self-discipline and overall motivation to study (Lake Research Partners, 2011).

Community college graduation rates. Although 47% of the nation's college graduates have been educated at a community college (AACC, 2013b), completion rates at community colleges are low when compared to more selective institutions (Jenkins, 2011). However, published graduation rates can be misleading, depending upon the time frame. Community college graduation rates were cited at 24%, but the federal commission recently found this statistic misleading because the time frame of three years is often too short to complete programs (AACC, 2013a).

Ideally, community college students can earn a degree in two years, but for some it is simply not plausible, with the amount of time they must spend on other responsibilities such as employment and family commitments. Most metrics regarding success, enrollment, and completion rates for community college students are measured over a six-year period (AACC, 2013a). Remedial and pre-requisite courses may be part of the cause and many students attend part-time due to financial constraints. A non-passing grade in a remedial course at any point in the semester greatly reduced a student's likelihood to progress to the next level (Bahr, 2010). Students that have not returned cannot always be tracked. Though many community colleges recognize that attrition rates are a serious problem, few have invested funding to address it (Engstrom & Tinto, 2001).

As summarized by Scott et al. (2010), students cited a variety of reasons for withdrawing from college, for example, being out of school for an long time, balancing employment and family responsibilities, being unprepared for the rigors of college, transportation issues, and lack of time to study. It takes students longer to complete STEM degrees, in some cases due to navigating the educational system in complex ways (NAS, 2016). This is why some students do not enroll in STEM; additional time spent for education not only costs more tuition but is also lost income (Bettinger, 2010).

According to Juszkiewicz (2015) and based upon National Student Clearinghouse data, the graduation rate over a six-year period for students that started out at two-year public institutions was 39% when taking into account those who transferred and graduated. The breakdown equates to: 26% completed at initial institution, 10% graduated after from a four-year institution, 3% from another two-year institution, 18% still enrolled, and 43% no longer enrolled (Juszkiewicz, 2015). Many reasons account for such attrition. Tinto (1993) stated that two-year institutions can expect that approximately three-fourths of their entering students will never finish a program or degree. At four-year institutions, between one-fourth and one-third of freshmen will drop out; at two-year institutions, more than 40% of freshmen drop out (Aughinbaugh, 2008; Walton, Berkner, Wheeless, Shepherd, & Hunt-White, 2010).

2.15 Conclusions

The community college population is unique in that students have many demands and responsibilities. Many community college students are older students, commuters, and degree holders returning for additional education. They come with a wealth and variety of life experiences. Adult Learning Theory states that the adult learners are different from children and therefore possesses different needs than children in compulsory educational settings. Finding relevance, building confidence, maintaining attention and being satisfied with what is being learned is important for the adult student to remain motivated and engaged. Wang (2013) stated that an understanding of the wide variety of past educational experiences should be considered in order to develop policies and interventions to benefit underrepresented students and improve their potential in STEM-related majors and careers. This study investigated the variety of factors that influenced community college students' interest and motivation to study science.

Motivation in science education is an important area of research. Understanding the relationships between various predictors is important to understand how increased motivation influences students to major and remain in the sciences. Making science interesting, fun and relevant seems to motivate students of all ages. Counselors at the high school level may play a role in students' choices, therefore, pathways of student learning and choice of major for college. Personal and social support systems, including community college faculty, can have a profound effect on motivation and academic performance. Students' motivation may be enhanced by increased autonomy and awareness of progress in their learning process.

Motivation may be due to the interplay of a variety of personal factors, and may not always be generalizable, because individuals have different values, beliefs, and circumstances. Combinations of these constructs affect our attitudes, which, in turn influence our motivation. Motivation affects behavior, learning, and performance. Elucidating the sources of intrinsic and extrinsic motivation and interest will be valuable for policy makers and instructors to develop strategies to maximize the success of community college students in STEM.

Chapter 3

Methodology

3.1 Research Questions and Rationale

Motivation to study science is a particularly important topic to research because few students are choosing and remaining in STEM majors and careers at every level of higher education, from post-secondary certifications to doctorates. This study focused on exploring interest in science as it related to individual, course, and instructor characteristics. The rationale for surveying community college students in a biology course was to elucidate whether and how students become more interested in science over the duration of the semester. Additionally, investigating students' interest in biology coursework and its relationship to personal characteristics gave insights into how to increase student interest in science and increase STEM enrollment and retention. The purpose of this study was to examine the following research questions:

1. How were the personal characteristics and backgrounds of community college students related to their interest, confidence, and motivation to enroll in science courses and pursue a science-related career?
2. How were student interest, confidence, and motivation to study science related to instructor characteristics?
3. How was the type of biology course in which community college students were enrolled related to student interest, confidence, and motivation?

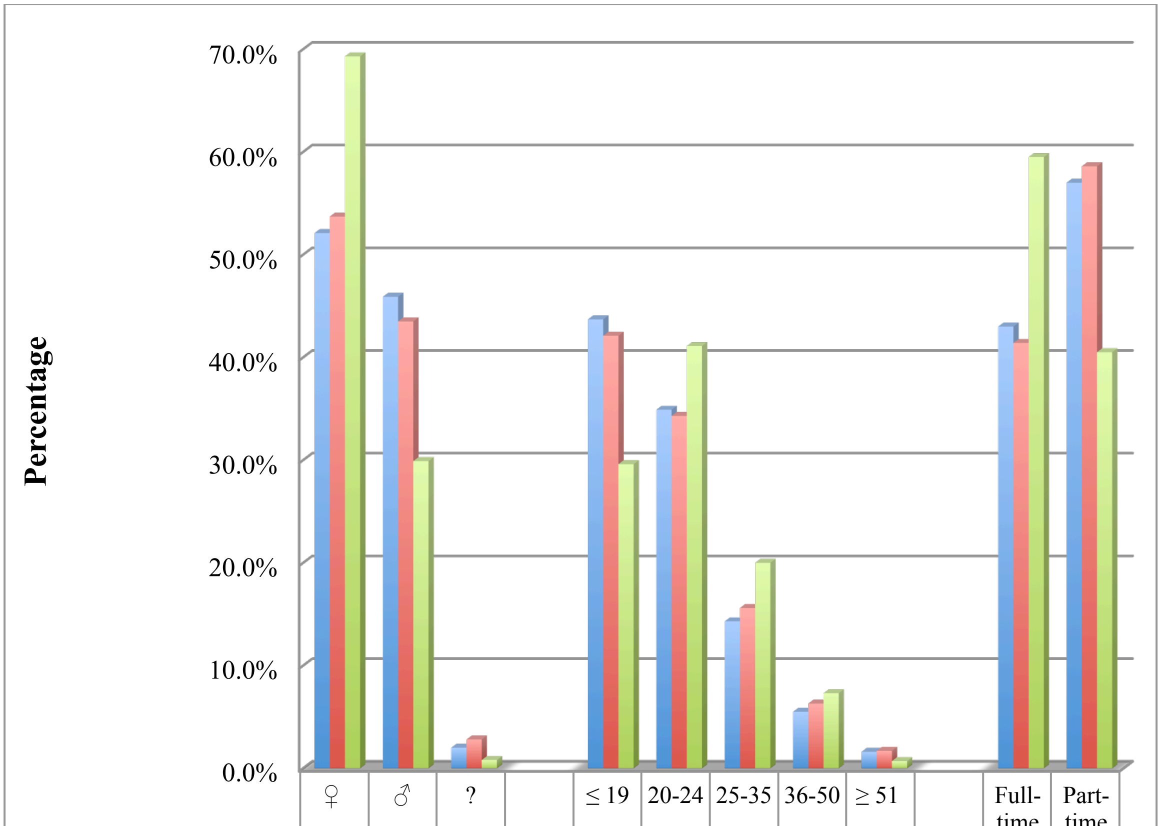
This chapter includes a brief rationale, procedures for obtaining approval for research with human subjects, student, instructor, and course sample information; research design, context, and data collection procedures; variables and methods of statistical analysis; reliability and validity evidence for the instruments; procedures for screening and details regarding the interviews; coding methods; and study limitations.

3.2 Procedures for Institutional Review Board Approval

The institution where the study took place approved this research on student interest, motivation, and confidence in fall 2014. A letter of support from the Institutional Review Board (IRB) of the community college where the study was performed was provided to the Stony Brook University (SBU) IRB Board, and full IRB approval from community college was obtained following SBU IRB approval of this research; the IRB approval number from SBU was #624226-3 and from the host institution was #14-005.

3.3 Sample

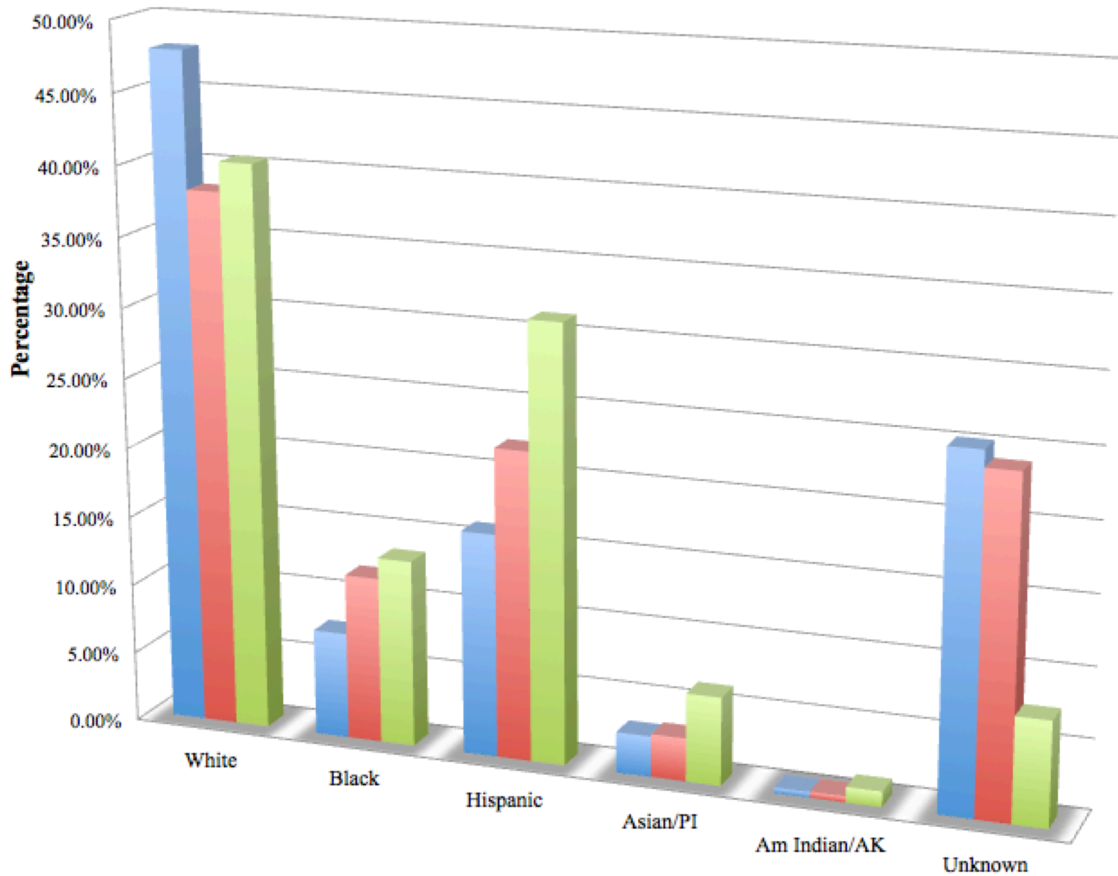
The sample was part of a large, suburban, multi-campus community college in New York State. The institution was comprised of three campuses enrolling more than 30,000 students in the fall 2014 semester, with one-third of the total student population attending the campus where the study was conducted, the most diverse of the campuses. The institution's gender percentages were 52% female and 46% male. Seventy-nine percent of the students were between the ages of 18 to 24, and 21% of students at this community college were 25 or older. Comparisons of the college percentages by gender, age group and student status to the campus population and survey participant sample can be viewed in Figure 2.



	♀	♂	?		≤ 19	20-24	25-35	36-50	≥ 51		Full-time	Part-time
College	52.1%	45.9%	2.0%		43.7%	34.9%	14.3%	5.5%	1.6%		43.0%	57.0%
Campus	53.7%	43.5%	2.8%		42.1%	34.3%	15.6%	6.3%	1.7%		41.4%	58.6%
Survey Participants	69.3%	29.9%	0.8%		29.6%	41.1%	20.0%	7.3%	0.7%		59.5%	40.5%

Figure 2. Context and participants by gender, age, and student status.

This institution's ethnic composition was as follows: 47.9% White, 7.6% Black, 16.0% Hispanic, 2.9% Asian/Pacific Islander, 0.4% American Indian, and 25.2% other/unknown. The study sample included students enrolled in biology courses at the most diverse of the three campuses. This campus was comprised of students that were 38.3% White, 11.9% Black, 22.1% Hispanic, 3.07% Asian/Pacific Islander, 0.43% American Indian/Alaskan, 0.17% nonresident/alien, and 24% unknown. A comparison of college, campus, and survey participant ethnicity is in Figure 3.



	White	Black	Hispanic	Asian/PI	Am Indian/ AK	Unknown
College-wide	47.90%	7.60%	16.00%	2.90%	0.40%	25.20%
Campus	38.30%	11.90%	22.10%	3.07%	0.43%	24.00%
Survey Participants	40.40%	13.40%	31.20%	6.30%	1.10%	7.50%

Figure 3. Context and participants by ethnicity.

The main sample for this study consisted of 875 students enrolled in 42 sections of biology courses. Of the 875 responses for the pre-CIS survey and demographic questionnaire, 59.5% of students were attending full-time and 40.5% were part-time students. These percentages differed from the college-wide and campus percentage of full-time students, being 43% and 57% respectively. Of the respondents for the pre-CIS and demographic questionnaire, 30.1% were from males. The majority of the respondents were women (69.9%) but differed a bit from the overall college ratios for gender. Regarding age, 71.6% of the participants were 18-24 years old, 28.4% were 25 or older. A considerable number of respondents (21.7%) were born outside of the U.S. The ethnicities of the respondents were as follows: 41.9% identified as White, 13.4% Black, 31.2% Hispanic, 6.5% Asian/Pacific Islander, 0.7% Native American/Alaskan, and 6.2% were not identifiable. All of the underrepresented populations in this sample were proportionally higher compared to the overall college-wide population, but fairly consistent with the campus percentages of underrepresented populations.

As part of the explanatory sequential research design, twelve subjects were interviewed to collect qualitative data to interpret quantitative findings. Seven interviewees were female: 1 Asian, 2 Hispanic, 1 Black and 3 White. Five interviewees were male: 2 Black, 1 Hispanic and 1 White. A maximum variation sampling technique (Patton, 1990) was employed whereby a variety of ethnicities were contacted to participate to be representative of the campus population. The use of such purposeful sampling allowed the researcher to describe key themes that were consistent among students of different sociocultural backgrounds.

3.4 Research Design

Mixed methods explanatory sequential model. A mixed methods study requires the researcher to base claims on pragmatic grounds by utilizing strategies of inquiry that involve collecting data that are simultaneous or sequential (Creswell, 2003). A mixed methods approach involves both quantitative and qualitative research methods. For this study, the quantitative research involved a pre-determined method using a questionnaire-type instrument that required statistical analysis. The qualitative methods employed open- and closed-ended questions in semi-structured interviews. Based on the answers from the Course Interest Survey (Appendix A) and Background Factors and Personal Experience Questionnaire (Appendix B), individuals were invited for interviews and were asked more in depth open-ended questions. This model was therefore termed *mixed methods explanatory sequential* because of the sequence of phases of data collection: quantitative followed by qualitative (Creswell, Plano Clark, Gutmann, & Hanson, 2003). The rationale for this model was that while the quantitative results contributed towards a general understanding of the research questions (Ivankova, Creswell, & Stick, 2006), analysis of qualitative data helped to refine and detail the quantitative results (Creswell, 2003; Rossman & Wilson, 1985; Tashakkori & Teddlie, 1998). The advantages to this method included straightforward results with the opportunity to explore those results in more detail (Ivankova et al., 2006). Use of mixed methods explanatory sequential design can be particularly helpful with explaining the emergence of unexpected quantitative results (Morse, 1991).

Survey administration techniques. Community college biology instructors who taught both the lecture and the laboratory components of the course were invited to participate in the fall 2014 data collection. This was done because instructor characteristics were being evaluated in this study and it might be difficult for the students to decide how to answer the survey questions if they had conflicting feelings about their lecture and laboratory instructors. The 29 instructors that were interested responded that they would permit the administration of the survey during class time. To maintain consistency the term *instructor* will be used throughout this document and should be read as synonymous with *professor*. The term professor will appear in the qualitative data section as part of direct interviewee quotations.

The researcher attended the 42 classes of various biology courses to distribute the surveys. Biology courses were specifically selected for a number of reasons: 1) they were the most numerous of all science courses offered at this campus; 2) there were too few chemistry and physics majors; 3) the majority of the biology courses at this campus enrolled students who were in a STEM major or had a STEM-related career goal (1/3 of the courses surveyed were electives for students in non-STEM majors or did not have STEM-related career goals); and 4) this would enable investigation into whether those students taking biology electives might consider changing to a STEM major. The choice to sample the biology courses provided a wider range of variables to measure in addition to providing a larger sample size overall.

At the scheduled appointment times, which were during the second and third weeks of classes, the researcher entered the classrooms and provided information related to informed consent, followed by the actual survey administration. The survey involved two parts: the Course Interest Survey (Appendix A, Keller, 2009) and the Background Factors and Personal Experience Questionnaire (Appendix B). The questionnaire included questions regarding high school science experiences, why the student chose to attend community college, why they chose to enroll in the biology course, their main motivation for choosing a science related career, and questions regarding various background factors. Permission to use the Course Interest Survey was obtained from the author by the researcher. The pre-course surveys yielded complete results from 875 students. The second administration of the Course Interest Survey was done after the 12^{th} week of the 15-week semester yielding 639 useful pre- to post-survey comparisons for the sample. This was done so that sufficient time had been given to observe changes that might have occurred in student interest, motivation and confidence, but prior to final exams.

Five questions generated by the researcher were also administered at the time of the post-Course Interest Survey. These questions proved important for not only gaining data from the students but were also used in providing external convergent validity. The five questions are listed below: the first three required a Likert scale answer of strongly disagree, disagree, neutral, agree or strongly agree, and questions 4 and 5 required yes or no.

1. I feel more *confident* that I could successfully complete another biology course due to what I have learned this semester.
2. I am more *interested in enrolling in another biology course* due to what I have learned this semester.
3. This course is *motivating* me to stay in or change to a science-related career.
4. Did you engage in a *science research project* that was NOT part of your course requirements? (Science research involves investigation to answer a question by manipulation of a variable through field or laboratory work.)
5. Did you perform a *library research* project in this course? (One example of a library research project was from an Introduction to Oceanography course. This involved students selecting a topic of their choice from a list of weather-related and biological topics associated with the ocean, or another alternative of their choice that was not listed that would be approved by the instructor. Students were required to do 5-minute presentation and a 5-10 page paper that included references and citations, and were graded according to a specific rubric.)

Survey participants remained anonymous by using a numerical code (last four digits of their student number) that was combined with a code number for their section so that information from the pre- and post-survey could be linked. Instructors were assigned a confidential code. The script for introducing the survey is found in Appendix C.

Instrument reliability, validity, and Rasch analysis. Reliability and validity were evaluated for the two instruments. Calculation of Cronbach's alpha for internal consistency reliability evidence for the overall instrument and for each of the factors was performed for both the pre- and post-CIS administration, as well as the additional questions given to the students during the pre- and post-survey administration. Cronbach's alpha for pre- and post-CIS overall and the four factors are in Table 1 and indicated acceptable reliability for the overall instrument and sub-constructs. The correlation between the pre- and post- measures for this sample was $r = 0.60$, $p < .001$. The maximum score for the 34 item CIS was 170. Nine items were stated in a negative manner and therefore were reverse coded before the scores were summed and used for statistical analysis.

Table 1
Reliability of Pre- and Post-CIS Surveys

Instrument/Construct	N	Cronbach's α	n
Pre-CIS overall	789	0.914	34
Attention, pre-CIS	845	0.801	8
Relevance, pre-CIS	848	0.789	9
Confidence, pre-CIS	836	0.706	8
Satisfaction, pre-CIS	820	0.780	9
Post-CIS overall	686	0.946	34
Attention, post-CIS	689	0.847	8
Relevance, post-CIS	686	0.827	9
Confidence, post-CIS	688	0.820	8
Satisfaction, post-CIS	690	0.870	9

Factor analysis was performed in order to provide internal structure validity evidence; the post-CIS results are reported in Table 2. The four factors of the CIS were abbreviated using the capital letter of each of them: A for attention, R for relevance, C for confidence, and S for satisfaction. Factor analysis was also performed so that each of the four factors contributing to interest could be investigated. Not all responses fell into previously established categories; therefore, external convergent validity evidence was gathered. External convergent validity was provided by performing Pearson correlations with the post-CIS results and three additional questions regarding interest, confidence and motivation at the time of the administration of the post-CIS survey. Three Pearson correlations were calculated: mean post-CIS and mean of the first three researcher generated questions above ($r = 0.69$); mean of CIS confidence factor questions of the post-CIS and mean of question 1 above regarding confidence ($r = 0.65$); and mean post-CIS scores and mean of the two other the questions 2 and 3 above ($r = 0.59$). All Pearson correlations were significant at the $p < 0.001$ level with medium effect sizes ($d = 0.47$, 0.42, and 0.35 respectively), providing external convergent validity to the CIS.

Table 2
Factor Analysis of Post-CIS Results

	Component			
Item	1	2	3	4
S 18	.673			
S 14	.641			
S 32	.636	.400		
C 34	.603	.443		
C 3	.599			
S 19	.592			
C 27	.580		.407	
S 33	.571			
C 17	.556			
C 6	.545			.505
C 30	.541			
S 7	.525			
C 9	.513			
A 24		.781		
A 21		.771		
A 1		.753		
R 22		.737		
A 10		.679		
A 15		.589		
R 5		.547		
A 29		.531	.451	
R 2			.714	
R 13			.676	
R 23			.672	
R 28			.661	
R 20			.655	
S 16		.486	.581	
S 12		.454	.566	
A 4				.643
R 8				.579
R 25			.530	.545
A 26				.544
C 11	.500			.503
S 31	.432			.437

Rasch Rating Scale Model Analyses (to provide person and item reliability and person and item fit) were also performed using WINSTEPS since a Likert scale survey was utilized. The results are shown in Table 3. Both person and item reliability for both the pre- CIS and post- CIS were above the cut off for acceptable measure (0.8 and 0.9 respectively) according to Popham (2006). If person reliability fell below 0.8 then more items may be necessary, and if item reliability was less than 0.9 then the person sample was not large enough. Person reliability fell below the 0.8 cut in each of the four constructs of the Course Interest Survey because each of them consisted of only 8 or 9 items. Item reliability was .99 or greater for both of the overall instrument and each of the four constructs on the post CIS, indicating the sample was large enough. According to Wright and Linacre (1994), the infit and outfit MNSQ values for rating scales should fall between 0.6 and 1.4 to be considered reasonable; as listed in Table 3, all values for the pre-CIS, post-CIS and the four constructs of the post-CIS fell within this range.

Table 3
Person and Item Fit Analysis for Pre- and Post-CIS

Instrument/factor	Measured	Type	IMNSQ	OMNSQ	Reliability
Pre-CIS	875	Person	1.09	1.12	.89
	34	Item	1.01	1.12	.99
Post-CIS	694	Person	1.09	1.09	.92
	34	Item	1.02	1.09	1.00
Attention, post-CIS	694	Person	1.03	1.05	.78
	8	Item	1.02	1.06	.99
Relevance, post-CIS	694	Person	.97	.94	.59
	9	Item	1.02	.94	1.00
Confidence, post-CIS	694	Person	.98	.98	.70
	8	Item	1.00	.98	1.00
Satisfaction, post-CIS	694	Person	1.05	1.02	.79
	9	Item	1.01	1.04	1.00

Interview selection and techniques. The researcher invited students to be interviewed regarding their interest in science and past educational experiences. Maximum variation sampling was performed to identify individuals who have expressed both very high and very low motivation, confidence, and satisfaction with their courses. Interviewees were also chosen based upon varying demographic characteristics, survey responses, and course sections. Interviews were conducted with 12 students in 45-minute sessions. Selected students who completed interviews received a $10 gift card.

The interviews were conducted in a semi-structured style to get specific details about the students' background in education, experiences, and life in general. Semi-structured was an important style choice because some students talked about aspects of their lives the script did not prepare for and lines of questioning for subsequent interviews were edited based upon earlier data collection. The semi-structured interview script can be found in Appendix D, and the consent form in Appendix E.

During the interview, subjects were asked how their previous educational experiences, work experiences, life circumstances and standardized testing in high school affected their motivation, and how far they planned to pursue their education in the future. Questions about their ways of life, way of thinking about science and life, cultural and family influences, motivations to study science, motivations for their career choice to be science related, future income goals, elementary and high school experiences in science, and exposure to information about STEM careers from high school guidance counselors and teachers were included in the interviews.

The audiotaped interviews were transcribed and analyzed by the interviewer using qualitative research methodologies. The recorded files were destroyed after transcription. Once transcription was done, individual interviews were coded, compared and patterns in the data were identified. A second coder analyzed the interviews and the results of both researchers were compared, corrected and revised during a discussion. This established the reliability of the qualitative results.

Data collection and study sample. Eight full-time instructors taught 19 of the sections and 21 part-time instructors taught 23 of the sections of biology courses chosen. The instructor codes, gender, professional and academic characteristics, and attrition rates for their courses are listed in Table 4. The attrition rate is based upon how many students withdrew from the course before the end of the semester. All biology courses at this institution have a maximum enrollment of 24 students, with the exception of microbiology, which has a maximum of 20 students for lab safety reasons.

Table 4
Instructor Codes and Characteristics

Instructor	FT or PT	Gender	High school teaching experience	Taken Educ. courses	Course numbers taught	Attrition rate	Degrees Obtained and Certifications
1	Full	Female	No	No	1	13%	B.A. in Biology M.S. in Biomedical Science - Neuroscience Ph.D in Biomedical Science - Neuroscience
2	Full	Male	Yes	Yes	1 1 1	8% 12.5% 0%	B.A. in Biology M.A. in Biological Science - Biotechnology Ph.D in Molecular, Cellular, & Developmental Biology
3	Full	Male	No	No	7 7	41.6% 41.6%	B.S. in Biology M.S. in Biology
4	Full	Male	No	No	4 4 7	29.2% 29.2% 25%	A.S in Biology B.S. in Biology M.A. in Biology Ph.D in Genomics & Systems Biology
5	Full	Male	No	No	8 8	37.5% 12.5%	A.A.S. in Medical Technology B.A. in Biology M.S. in Physiology
6	Full	Female	Yes	No	9 9	15% 35%	B.S. in Biology M.S. in Biology Ph.D in Microbiology
7	Full	Female	No	No	6 9 9	15% 25% 10%	A.S. in Biology B.S. in Biology M.S. in Biology PhD in Microbiology
8	Full	Female	Yes	Yes	2 3 3	0% 4.1% 0%	B.S. in Biology M.S. in Biology Ph.D in Molecular Genetics
9	Part	Male	Yes	Yes	1	16.7%	B.S. in Marine Science- Biology M.S. in Marine Science- Biology *Certification in teaching high school science
10	Part	Male	Yes	Yes	1	8.3%	B.S. in Biology M.S. in Biology *Certified in secondary education biology
11	Part	Male	Yes	Yes	1 1	8.7% 9%	B.S. in Biology *Certification to teach *after* 1 year teaching
12	Part	Female	Yes	Yes	1	4.3%	Double B.S. in Biology & Secondary Education M.A. in People in Education *Certified to teach high school biology
13	Part	Male	No	No	7	17.4%	B.S. in Biology Doctor of Osteopathy
14	Part	Male	No	No	7	0%	B.S. in Biology Ph.D in Radiation Biology
15	Part	Female	Yes	Yes	7	16.7%	B.S. in Biology M.S. in Biology *Certification to teach secondary education science
16	Part	Male	No	Yes	7	25%	B.S. in Biology M.A. in Biology

							M.S. in Physiology Ph.D in Histology and Biochemistry
17	Part	Male	Yes	Yes	8	21.7%	B.S. in Psychology M.S. in Biomedical Science *Certification in secondary education science & math
18	Part	Male	Yes	Yes	8	0%	B.S. in Biology M.S. in Biology M.S. in Education
19	Part	Female	No	Yes	8	29.2%	B.S. in Biology M.S. in Biology M.S. in Education
20	Part	Female	No	Yes	10	9.5%	Double B.S. in Biology & Education Ph.D in Genetics
21	Part	Female	*only student teaching	Yes	11 11	0% 0%	B.S. in Biology M.S. in Biology M.S in Adolescent Education – Earth Science
22	Part	Male	No	No	4	0%	B.S. in Biology Ph.D in Biophysics
23	Part	Female	No	Yes	4	4.2%	B.S. in Biology M.A in Teaching Biology M.S. in Genetics
24	Part	Female	Yes	Yes	5	4.2%	B.S. in Biology M.A. in Education- Secondary Science M.S. in Molecular Biology & Immunology
25	Part	Male	Yes	No	5	0%	B.S. in Marine Biology M.S. in Animal Behavior *Certification in administration
26	Part	Female	No	No	9	10%	B.S. in Biology, minor in Environmental Policy M.S. in Biology - Microbiology
27	Part	Male	No	No	9	0%	B.S. in Biology Ph.D in Biochemistry
28	Part	Female	No	No	2	4.5%	B.S. in Marine Science- Biology M.S. in Costal Zone Management
29	Part	Female	Yes	Yes	2	9.1%	B.S. in Engineering M.S. in Geology *Certification in secondary education earth science

3.5 Statistical Design

Descriptive and inferential statistical techniques were employed to explore factors related to student interest in introductory biology coursework. The independent variables were related to student, course, and instructor characteristics. The dependent variables were as follows: post-CIS scores, difference (from pre- to post-) in CIS scores (or *change score*), the 3 questions following the post CIS about confidence, interest, and motivation to further study science. The Background Factor and Personal Experience Questionnaire contained a rich data set of independent variables that were used for paired samples *t*-tests, Pearson correlations, analysis of covariance (ANCOVA), and binary logistic regression.

Variables, statistical tests, hypotheses. Several comparisons were done among the types of sections to investigate the effects that demographic variables, prior educational experiences in science, parental status, and career goals had on interest, motivation, and confidence to study science, and to determine whether correlations existed between these independent and dependent variables. The hypotheses were summarized, along with the statistical analyses that were used to address the research questions, and are listed in Table 5.

Table 5
Null Hypotheses with Respective Variables and Statistical Tests

Null Hypotheses	Independent Variables	Dependent Variables	Statistical Tests
RQ 1. The personal characteristics and backgrounds of community college students will not affect their interest, confidence, and motivation to enroll in science courses and pursue a science-related career.	<u>Dichotomous</u> Age groups Gender Parental status Females that were mothers/not Males that were fathers/not Foreign/US born Degree holder/not Full time/part time Employed/not Two or more jobs/not High school science research/not Have a career goal/not STEM-related career goal/not Declared major/not Students state study enough/don't Money a factor in choice/not STEM career aware/not Understand science research/not <u>Nominal</u> Country of birth Ethnicity No job/one job/multiple jobs Major: groupings Ultimate career goal: groupings Reasons for not studying enough Reasons not taking more HS science	Change score pre- to post CIS	ANCOVA
	Likert scale answer to statements in Background factors and Personal Experiences Questionnaire. Likert scale response to 3 questions regarding confidence, interest and motivation to study science that accompanied the post-CIS	Mean pre-CIS scores and post-CIS scores	Comparison of means and standard error
RQ 2. The instructor characteristic will not affect student interest, confidence, and motivation to study science.	Taken education courses/not Has an education certification/not Has an education degree/not Has PhD/not Full-time/part-time instructor Has taught high school/not Male/female instructor Instructor gender same as student Instructor gender opposite of student	Change score pre- to post-CIS	ANCOVA

RQ 3. The type of biology course in which community college students are enrolled will not affect student interest, confidence, and motivation to study science.	Course number Course type: majors, elective, service, programmatic Attrition < 10%, attrition ≥ 10% Daytime/evening course Weekday/weekend course Library research assignment/not Voluntary science research project/not	Change score pre- to post-CIS	ANCOVA
Additional analyses that address all three of the research questions.	All of the independent variables listed above	Interest increased or decreased	Binary logistic regression
	Likert scale response to 3 questions regarding confidence, interest and motivation to study science that accompanied the post-CIS (all 3 questions together and individually)	Change score pre- to post-CIS	Comparison of means and standard error Pearson correlation

3.6 Categories of Courses Surveyed

Four categories of classes were surveyed. Electives were courses that any student could take to fulfill their lab science requirement for graduation. Major courses were those that were either required (Modern Biology I and II) or recommended depending upon the transfer pathway (Microbiology). Service courses were those that were taken predominantly by those who were taking pre-requisites to apply to an allied health program such as nursing. The programmatic requirements were courses that had to be taken by certain programs, but in some cases were taken by other students to fulfill their lab science graduation requirement. *Fundamentals of Human Structure and Function* was a course that had to be taken by the Health Information Technology majors, and *Zoology* was required for the Veterinary Science Technology majors. Figure 4 shows the breakdown of courses and the number of each in the four categories; the majors and service courses are stacked in a pyramid shape to note that these are sequence courses. The first course taken is at the bottom and the last course is on top. Course code numbers and descriptions are found in Appendix F.

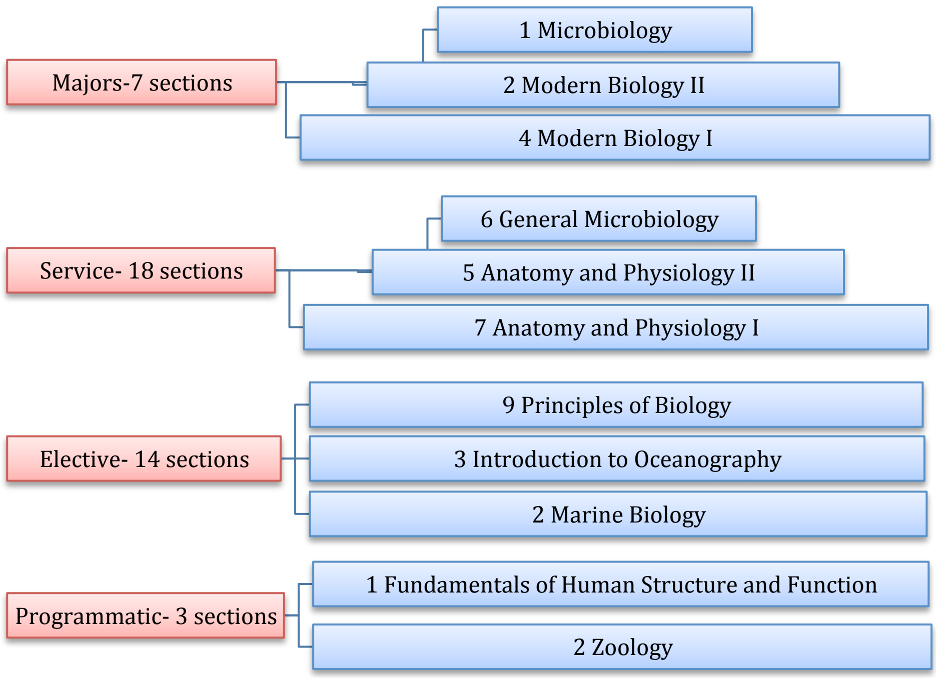


Figure 4. Biology sections surveyed, listed by category and number of sections.

3.7 Quantitative Analyses

Likert-type responses were listed in the Course Interest Survey, many questions in the Background Factors and Personal Experience Questionnaire, and three of the five additional questions administered with the post-CIS. Surveys were analyzed with SPSS Statistical Software. SPSS and WINSTEPS were used to generate reliability and validity evidence. Quantitative methods of analysis using SPSS included: paired samples *t*-tests, Pearson correlations, analysis of covariance (ANCOVA), and binary logistic regression.

ANCOVA was used for examining numerous categorical variables and continuous (scale) variables as individual predictors for the dependent variable. The dependent variable was the difference between pre- and post-CIS score and the pre-CIS score was the covariate. Change scores are reliable and increase the likelihood of making causal inferences from non-experimental data (Allison, 1990). Change score has been shown to show little to no bias and is equally or more powerful than a test score measurement where error may exist (Oakes & Feldman, 2001). Effect size was measured by Cohen's *d*. Levene's test for equality of error variance was calculated. Normality of distribution was checked using Shapiro Wilk's test and viewing normality plots and histograms.

Binary logistic regression was performed to identify the most important factors that suggest why student interest changed over the course of the semester, and how accurately a combination of variables predicted the outcome. The independent variables used for the regression analysis were checked for collinearity.

3.8 Qualitative Analysis

Grounded theory. Qualitative analysis of the interviews transcripts was done using grounded theory and a phenomenological approach. The qualitative data were used to explain elements of the quantitative results. Grounded theory was introduced in 1967 as a way to study a collection of concepts in order to produce an explanation and description of a sociological phenomenon (Corbin & Strauss, 1990). There are two important principles drawn from *pragmatism* and *symbolic interactionism* that helped inform grounded theory (Corbin & Strauss, 1990). Pragmatism embraces social science research with multiple methods of research and "operates in a critical mode as a critique of critiques and in a post-liberal mode as a reconstruction of individual and communal life" (Maxcy, 2003, p. 54). Symbolic interactionism has three basic premises: the subject act towards things based on the meaning those things have in their lives, the meaning comes from social interactions that the subject has with others, and those meanings possibly change due to experiences (Blumer, 1969). The first principle of grounded theory is regarding change; phenomena are dynamic, therefore, it is crucial to employ grounded theory to account for and adjust to change. The second principle pertains to determinism, or how one responds to the changing conditions. It is important that the researcher notes the interaction between change and how the subject responds to change. Pragmatism and symbolic interactionism share the idea that the subject has the ability to make choices based on their perceptions of their own environment (Corbin & Strauss, 1990). Grounded theory is a discovery process that produces a theory that is grounded in reality (Glaser & Strauss, 1967). This process was crucial in discovering patterns in student choices related to course interest and their career goal motivation.

Coding process. Interview data and survey data were coded in similar manner (Glaser & Strauss, 1967). It is essential to start data analysis at the very beginning of the interview or observation process, because future data collection might be altered based on initial analyses (Corbin & Strauss, 1990). This is why the choice of semi-structured interview style was important. There were three types of coding employed: open, axial and selective. *Open coding* was performed first; this was an analytical process of data interpretation in which events or interactions were compared to detect similarities or differences (Corbin & Strauss, 1990). Events were categorized and subcategories were formed. Detection of categories helped to formulate further lines of questioning in subsequent interviews (Corbin & Strauss, 1990). Open coding has also been referred to as *initial coding* (Charmaz, 2014) because it describes an introductory procedure in the first cycle of coding (Saldaña, 2016). Charmaz described initial coding by stating the researcher should "remain open to all possible theoretical directions suggested by your interpretations of the data" (Saldaña, 2016, p. 115).

Saldaña (2016) described *eclectic coding* as a transitional step that occurred between the first and second cycle of coding, although it was originally described as a form of open coding by Glaser and Strauss (1967). Eclectic coding was difficult to categorize, but fell in line with an exploratory method of coding where the researcher started with an initial draft of codes and revised them into a second draft before moving on to the second cycle of coding (Saldaña, 2016). Eclectic coding can also be described as what is happening when the researcher utilizes complimentary combinations of more than one method during the first cycle (open or initial coding) due to what emerges from initial impressions of the data (Saldaña, 2016).

The second stage of coding, *axial coding*, associated categories with the subcategories from the open coding and examined the relationships between them (Charmaz, 2014). Axial coding is related to the idea that alternating data collection and analysis is essential for developing a strong theory (Corbin & Strauss, 1990). During the process of axial coding, categories continually evolved through patterns and trends identified in the data. At the same time the categories were related to subcategories using "conditions, context, strategies and consequences" (Corbin & Strauss, 1990, p. 13). Axial coding served as a data reduction technique and assisted further refining the lines of questioning in semi-structured interviews (Corbin & Strauss, 1990). The goal of this constant comparative analysis (Corbin & Strauss, 1990) led to theoretical nexus regarding individual student characteristics and experiences with interest, motivation and confidence to study science. Axial coding was the transitional step between initial and *selective coding* (Saldaña, 2016).

Selective coding was performed last. Selective coding required unification of all categories around a core category that represented the phenomenon on which the whole study was centered (Corbin & Strauss, 1990). The goal of this step was to discover what is referred to as the *central* or *core category* in grounded theory (Saldaña, 2016). The theoretical code(s) described the relationships between the categories in order to transform the analytical to theoretical (Charmaz, 2014).

The qualitative data was used to help explain the quantitative results, as the selective codes were linked to the theoretical framework of the study. Methodological triangulation ensured that the research questions were adequately addressed, as qualitative data corroborated what was found in the quantitative results. This was a process in which at least two methods, usually quantitative and qualitative research, were employed in order to address the research questions comprehensively (Morse, 1991).

Coding techniques used in this study. The researcher employed several formulaic coding methods, which fell into the categories of grammatical, elemental, and affective methods (as described by Saldaña, 2016) during open or initial coding phase. The researcher started by reading one of the twelve interview transcripts and writing down descriptive phrases of statements regarding previous educational experiences and personal factors related to science interest. Emotion and value coding were classified as affective methods and were the first formulaic coding procedures. *Emotion coding* labeled feelings while *value coding* described dynamics between the interviewee's values, attitudes, and beliefs (Saldaña, 2016). As more interviews were read, new open codes emerged. The researcher then assigned alphanumeric designations to each of the existing codes and listed emerging codes in a similar manner. The alphanumeric designations for the existing open codes were aligned with the four constructs of the Course Interest Survey: attention, relevance, confidence, and satisfaction. The use of a priori constructs is referred to as *structural coding* (Namey, Guest, Thairu, & Johnson, 2008). The researcher found that some codes fell into more than one of the four constructs and cross-listed those open codes where appropriate. The researcher then went back to the interviews that had already been coded and insured the appropriate cross-listed codes and newly emerging codes were recorded. When a qualitative datum had two or more codes that overlapped or were applied to it, it was referred to as *simultaneous coding* (Saldaña, 2016). A few new open codes emerged with subsequent readings. Some of the codes had positive or negative effects on the interviewee and this datum was also recorded by the researcher; this process was referred to as *magnitude coding* (Saldaña, 2016).

The researcher re-read all of the interviews thoroughly to note if any of the latter emergent open codes applied to earlier interviews. Additionally, the second read helped to insure that simultaneous coding was done correctly. Some of the wording of the open codes was edited during the second read through to reflect more detail regarding the code. The combination of these processes employed is described as *eclectic coding* by Saldaña (2016).

Twelve interviews were sufficient to reach *theoretical saturation*. Not many new open codes emerged in the latter interviews of this study. Morse stated that "saturation is key to excellent qualitative work… there are no published guidelines or adequate tests of adequacy for estimating the sample size required to reach saturation" (1995, p. 147). Studies designed and data analysis by Guest, Bunce, and Johnson (2006) showed that saturation had occurred by the time they had completed twelve interviews. They noted that early codes tended to recur, be the most important, and that new themes emerged very infrequently as interviews increased past twelve. In one study 92% of the codes had emerged in the first twelve of thirty interviews, and in a second study 88% of the codes emerged in the first twelve of sixty interviews. If the purpose of the study is to describe comparable perceptions, beliefs, and behaviors in a group, then a sample of twelve is likely to be ample (Guest et al., 2006).

After the first cycle of coding was complete, axial coding was performed to see what categories would emerge from grouping open codes. The categories derived during axial coding were: altruism, childhood struggles, academic support structures, external support leading to mobility, personal motivation, and pride and self-esteem. The axial codes were used to develop the central or core categories in the qualitative data. From this selective or theoretical coding process the themes that emerged were consistent with the theoretical framework and will be discussed further in the next chapter.

After completion of the coding process by the first researcher, a second researcher confirmed the codes and discussed any discrepancies with the first researcher. Discussion followed by appropriate adjustments and corrections were made so there was agreement between the independent coding schemes and major themes. The second researcher agreed that twelve interviews were sufficient to reach saturation.

3.9 Study Limitations

Researchers must exhibit reflexivity, that is, acknowledge the personal relationship to the research subjects and the material being studied (Parker, 1994). Therefore, bracketing was necessary in order to reduce biases. Bracketing, or epoché, requires setting aside one's understandings and perceptions of the world as if to observe a phenomenon for the first time, though this is never completely possible (Langdridge, 2008). While the researcher was an associate professor at a community college, none of the researcher's students were part of this study. The researcher was familiar with the student demographic and the challenges of the community college student population, which led to the development of this study and its design. The researcher was a professional who has been a part of many search committees for full-time instructors, and as an administrator had interviewed, hired, observed and evaluated part-time instructors.

Since the students were all from the same campus of the same community college and were only sampled from biology courses, the sample was not completely random. It was the belief of the researcher that since the largest and most varied student sample could be obtained from biology courses this was the best discipline for the study, yet questions of generalizability across all STEM-related majors arose. While biology courses are not generalizable to all STEM fields, there were twice as many health-related STEM careers in the U.S. than non-health related STEM occupations in 2010 (NYSDL, 2016). Since biology courses are required for healthcare related careers, in addition to other STEM careers, it is a viable STEM population to study. The sample was comparable with respect to the national average for ethnicities, with the study sample being slightly higher in the Hispanic group. The sample also had more students under 21 years old, as well as more females, when compared to the national average (AACC, 2015b) and when compared to the campus as well as overall college populations.

Some of the students were lost from administration of the pre- to post- survey, perhaps due to attrition or perhaps due to not attending class that day, but there is no way to be certain. Some students that did participate in both of the surveys did not answer all questions and their data were excluded from the quantitative analyses.

Another limitation was that the study results were not tied to student outcomes. It was decided that it would become too unreliable to have students self-report their grade point averages and too difficult to obtain from the institution.

Chapter 4

Results and Discussion

4.1 Introduction

The purpose of this study was to investigate the interest, confidence and motivation of community college students enrolled in a biology course and the various student, instructor and course characteristics that affect these constructs. Both quantitative and qualitative methods were utilized. This chapter will be organized into several sections in order to address the following research questions:

1. How were the personal characteristics and backgrounds of community college students related to their interest, confidence, and motivation to enroll in science courses and pursue a science-related career?
2. How were student interest, confidence, and motivation to study science related to instructor characteristics?
3. How was the type of biology course in which community college students were enrolled related to student interest, confidence, and motivation?

There were several quantitative analyses in the overall study. First, student characteristics and background factors were analyzed by descriptive statistics, ANCOVA, and comparison of means. Instructor characteristics and characteristics of individual courses such as attrition and types of assignments were explored by descriptive statistics and ANCOVA. Following these analyses, binary logistic regression was performed to elucidate what combination of independent variables best predicted what affects student interest during their biology courses. Qualitative data from twelve student interviews were discussed in relation to the four constructs of the Course Interest Survey: attention, relevance, confidence and satisfaction. Connections between quantitative and qualitative data were identified.

Summary of methods. Several methods were employed to answer the research questions. Descriptive statistics and comparison of means from Likert-type questions from the Background Factors and Personal Experiences Questionnaire (Appendix B) identified factors that influenced student interest, confidence, and motivation to enroll in biology. ANCOVAs were performed on Course Interest Survey (CIS, Appendix A) change scores, controlling for pre-CIS score, comparing means for fixed factors associated with several categorical variables. Comparisons of means of pre- to post-CIS scores measured differences in their interest from the beginning of the semester compared to the end of the semester in relation to how they answered Likert-type questions regarding various aspects of their motivation. Binary logistic regression was performed to elucidate the combination of the most important student, instructor and course factors for potential interventions to increase interest. Semi-structured interviews of students were performed following the first administration of the surveys. Interview transcripts were coded according to the principles of grounded theory and the core categories of the coding process were related to the theoretical framework of the study in order to analyze and expand upon quantitative findings.

Overall change in course interest. A paired-samples *t*-test for repeated measures revealed that overall student interest significantly decreased from beginning to the end of the semester for the total sample. There was a significant decrease in the scores from the pre-CIS score (M=131.53, SD=17.11) to the post-CIS (M=128.33, SD=23.69); $t(635)=-4.20$, $p < .001$, d=0.17. This decline in interest had a relatively small effect. Interpretation of strength of relationship when using (Cohen's) *d* to measure effect size was: ≥ 1.00 very large, 0.80 large, 0.50 medium, and 0.20 small (Cohen, 1988). However, in regard to education research, effect sizes of 0.20 (or even less) are typically of interest and are relevant to affect policy change (Hedges & Hedberg, 2007). As Hedges and Hedberg pointed out, the use of a covariate considerably increases the statistical power it often decreases the effect size (2007). Statistical power refers to the long-term probability to reject the null hypothesis and takes significance criterion, effect size, and sample size into consideration (Cohen, 1992).

Change in the sub-constructs of course interest. A paired samples *t*-test for repeated measures revealed significant decreases in three of the four individual constructs of the CIS: relevance, confidence, and satisfaction. Attention was not significant. The maximum score for relevance and satisfaction was 45, whereas the maximum score for attention and confidence was 40. There was a significant decrease in relevance from pre- (M=37.93, SD=5.14) to post- (M=36.65, SD=6.19); $t(675)=-6.93$, $p < .001$, d=0.23, a small effect. There was also a significant decrease in confidence pre- (M=32.18, SD=4.42) to post- (M=31.15, SD=6.05); $t(668)=-6.93$, $p < .001$, d=0.19, a small effect. Satisfaction significantly decreased from pre- (M=32.97, SD=5.94) to post- (M=32.37, SD=7.92); $t(672)=-2.20$, $p < .05$, d=0.09, a negligible effect. The attention construct did not yield significant results, decreasing from pre- (M=28.29, SD=5.87) to post- (M=28.00, SD=6.83); $t(674)=-2.20$, $p = 0.17$. These results showed that not only did overall interest significantly decrease but that three of the individual constructs of interest did, as well, suggesting students could benefit from conditions that increase relevance, confidence and satisfaction (Table 6).

Table 6

Paired Samples t-Test Results for the Four Constructs of the CIS

		pre-		post-		
CIS Construct	*N*	*M*	*SD*	*M*	*SD*	*t*
Relevance	676	36.93	5.14	36.65	6.19	-6.93**
Confidence	669	32.18	4.42	31.15	6.05	-4.60**
Satisfaction	673	32.97	5.94	32.37	7.92	-2.20*
Attention	674	28.29	5.87	28.00	6.83	-1.38

*$p < .05$, **$p < .001$

Change in confidence, interest and motivation in relation to change in CIS. Three Likert-style statements were administered with the post-CIS (Table 7). These statements were used provide the external convergent validity evidence for the CIS (as discussed in section 3.4). The same pattern was witnessed for the all three statements: students who agreed with the statement had a significant increase in interest, those who disagreed with the statement had a significant decrease in interest. Significant difference was determined by comparison of means with standard errors. The majority of the students agreed with statements regarding an increased confidence, motivation, and interest due to their biology course. The students that agreed with these statements also showed a significant increase in interest over the course of the semester as a result of their CIS change score, and those who disagreed with these statements showed a significant decrease interest in their biology course as a result of their CIS change score. These constructs were particularly relevant to the study and the questions were specifically designed to include components of the theoretical framework. The trends in these data strengthened and verified the relationship between confidence as a construct of interest and interest as a construct of motivation. Appendix G contains figures that display bar charts with standard error bars for these statements.

Table 7
Comparison of Means Regarding Confidence, Interest, and Motivation

	Pre-CIS S.A./Agree		Post-CIS S.A./Agree		Pre-CIS S.D./Disagree		Post-CIS S.D./Disagree	
Statement	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SD*)
I feel more ***confident*** that I could successfully complete another biology course due to what I have learned this semester.	402	136.73 (0.80)	401	139.97 (0.83)	80	117.88 (2.02)	80	97.64 (2.07)
I am more ***interested*** in enrolling in another biology course due to what I have learned this semester.	307	137.36 (0.89)	307	139.95 (1.05)	162	123.74 (1.44)	162	111.49 (1.83)
This course is ***motivating*** me to stay in or change to a science-related career.	291	137.90 (0.95)	291	140.65 (1.10)	184	125.26 (1.30)	184	113.47 (1.77)

Process for measuring change in course interest. Analysis of covariance (ANCOVA) was performed in order to determine whether differences in individual independent variables affected the change in students' interest. The covariate for each of the ANCOVAs was the pre-CIS score. For every case included in ANCOVA, the assumption of equality of variance was met, and data were normally distributed as visualized by histograms. The estimated marginal means and effect sizes were reported.

4.2 Relationship of Student Characteristics to Changes in Interest, Confidence, and Motivation: Quantitative Results

This section is organized by type of statistical analysis and the subtopic of each of those statistical tests. Descriptive statistics for student characteristics are listed first, followed by

ANCOVAs for student characteristics that yielded significant results. The rest of this section was organized according to comparisons of means that yielded significant differences. Those were grouped according to categories on the questionnaire. Only results that were significant and addressed the research questions were included. Each of these categories was related to students' interest in science in the main areas: 1) feelings about their high school courses, 2) reasons for registering for this biology course, and 3) main motivation for student career goal.

Only select significant results are discussed in this chapter. Those that can be used to triangulate data with the outcomes of the qualitative portion of the study will be discussed in this particular subsection. Some of the variables that were not significant in the ANCOVA played a significant role in the binary logistic regression model once a number of independent variables were combined.

Student background factors and course interest. ANCOVA for age yielded a significant difference in change in interest between the student age groups of 18-24 and 25 and older, $F(1, 630) = 16.56$, $p < .001$, $d = 0.33$. The adjusted (or estimated marginal) mean difference from pre- to post-CIS for older students ($M = 2.02$) compared to younger students ($M = -4.40$) had a small/medium effect size. Students 25 and older had a significant increase in interest in their biology course from the beginning to the end of the semester, while the mean of the students aged 18-24 showed that the younger students' interest in their biology class decreased. In a paired samples t-test for the 18 to 24 age group there was a significant decrease in interest from pre- (M=130.36, SD=18.10) to post- (M=125.80, SD=23.75); $t(464)=-5.09$, $p < .001$, d=0.22, which is a small effect.

Similar effects were observed when investigating students that were degree holders (M = 1.54) compared to those having no higher education degree prior to enrolling in biology (M = -4.29), where $F(1, 631) = 10.29$, $p < .01$, $d = 0.26$, with a small effect size. In a paired samples t-test, the non-degree holders exhibited a significant decrease in interest from pre- (M=130.73, SD=18.21) to post- (M=126.65, SD=24.23); $t(496)=-4.66$, $p < .001$, d=0.19, a small effect. The few personal characteristic variables that predicted course interest were a positive outcome in that these predictors cannot be controlled. Instructor and course variables can be influenced to some extent by community college policies and practices. Table 8 contains the descriptive statistics including the sample size of each comparison group, adjusted means, standard errors, and confidence intervals for all student characteristic variables that passed Levene's test for homogeneity of variance.

Table 8
Descriptive Statistics for Student Characteristics and Course Interest

Subgroups	*N*	*M* (SE)*	95% CI
Age 18-24	467	-4.90 (0.87)	[-6.60, -3.20]
Age 25 and older	166	2.02 (1.46)	[-0.84, 4.88]
No degrees	499	-4.29 (0.84)	[-5.94, -2.65]
Degree holders	135	1.54 (1.61)	[-1.63, 4.70]
Male students	195	-3.06 (1.36)	[-5.72, -0.39]
Females students	439	-3.16 (0.90)	[-4.93, -1.38]
US born student	520	-3.53 (0.83)	[-5.17, -1.90]
Foreign born student	107	-1.45 (1.84)	[-5.06, 2.16]
Full-time student	387	-3.83 (0.96)	[-5.72, -1.93]
Part-time student	244	-2.27 (1.22)	[-4.66, 0.12]]
Student has STEM-related career goal	475	-3.78 (0.87)	[-5.49, -2.07]
Not STEM-related career goal	161	-1.16 (1.51)	[-4.13, 1.81]
Students that are parents	72	-2.13 (2.23)	[-6.51, 2.24]
Non-parents	534	-3.30 (0.82)	[-4.91, -1.70]
Female students that are mothers	58	-3.79(1.03)	[-5.81, -1.78]
Not mothers	356	-1.35 (2.54)	[-6.35, 3.64]
Male students that are fathers	9	-4.08, (5.90)	[-7.63, 15.76]
Not fathers	100	-2.81 (1.77)	[-6.32,0.70]
Students that state they study enough	216	-2.31 (1.31)	[-4.87, 0.26]
Students that state they do not study enough	409	-3.36 (0.94)	[-5.22, -1.51]
Student is employed outside the home	559	-3.54 (0.80)	[-5.10, -1.95]
No job outside the home	75	-0.34 (2.19)	[-4.64, 3.95]
Student has more than 2 or more jobs outside the home	128	-2.84 (1.72)	[-6.21, 0.54]
Student has less than 2 jobs	381	-3.76 (1.00)	[-5.72, -1.81]
Performed a high school research project	332	-2.27 (1.04)	[-4.31, -0.22]
No high school research project	299	-3.89 (1.10)	[-6.04, -1.73]
Money not a factor would have chosen another path	177	-1.52 (1.44)	[-4.33, 1.30]
Not have chosen differently	423	-4.18 (0.92)	[-5.99, -2.37]
Understands science research	369	-2.96 (0.99)	[-4.91, -1.01]
Doesn’t understand science research	266	-3.39 (1.17)	[-5.69, -1.09]

Only the student characteristics that showed significant change in CIS when the ANCOVA are listed in Table 9.

Table 9
ANCOVA for Student Characteristics and Course Interest

Variable(s)	*df*	*F*	Significance	Cohen's *d* (η_P^2)
Age 18-24, 25 and older	630	16.56	.000**	0.33 (0.026)
Previous degree holders	631	10.28	.001*	0.26 (0.016)

*$p < .01$, **$p < .001$

Student high school experiences and college and career motivations related to course interest. The investigation of student characteristics continued by exploring students' high school experiences in science, personal motivations for career choice, reasons for enrolling in biology courses, and how these factors related to change in course interest. These comparisons provided additional insights and informed the semi-structured interview questions.

For these comparisons, students were placed in two groups. All of the students that responded strongly agree and agree to each individual Likert-type question in the Background Factors and Personal Experiences Questionnaire (Appendix B) were grouped together, as were students who responded strongly disagree and disagree. Their mean pre-interest scores were compared to their mean post-interest scores in order to see if their interest changed significantly over the course of the semester. The data showed the numbers of students that agreed or disagreed with each statement in which the statements were grouped into categories. All of the statements listed in the table showed a significant change of interest. Additional bar charts to represent the data are included in the appendix where indicated.

Students' feelings about high school science courses related to change in interest. Students responded to several statements related to their high school science courses and their awareness of STEM careers before college, and their course interest responses were evaluated by whether they agreed or disagreed with the four statements (Table 10). Appendix H contains figures that display bar charts with standard error bars for these statements.

Table 10
Comparison of Means Regarding High School Experiences and Course Interest

		Pre-CIS S.A./Agree		Post-CIS S.A./Agree		Pre-CIS S.D./Disagree		Post-CIS S.D./Disagree	
Category	Statement	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SE*)
My high school science courses:									
	Had a negative effect on my major and career goal.	67	125 (2.50)	52	123.81 (3.30)	517	131.98 (0.77)	421	130.08 (1.14)
	Were NOT interesting to me.	155	127.75 (1.58)	123	129.09 (2.09)	471	133.12 (0.78)	385	129.98 (1.20)
	Were fun.	395	132.89 (0.89)	318	1289.05 (1.36)	113	125.49 (1.64)	86	127.84 (2.45)
When I was in high school, I was made aware of STEM careers available for me to study in college.		247	133.39 (1.12)	198	129.33 (1.79)	351	128.18 (1.01)	287	128.81 (1.35)

Students that disagreed with the statement "My high school science courses had a negative effect on my major and career goal" had a significant decrease in interest from beginning to the end of the semester. These students had positive feelings about their high school science courses yet they decreased interest in their biology courses.

The statement: "My high school science courses were not interesting to me" also yielded a significant decrease in interest for students who disagreed with that statement. The majority of students were interested in science during high school but lost interest from beginning to end of their college biology courses. Once again, this raises questions about student course experiences that might be related to the drop in interest in their college biology course.

There was a significant change in interest for both groups regarding whether they thought high school coursework was fun. The interest of the students that said high school science was not fun significantly increased over the semester in their college biology courses, which was encouraging. Unfortunately, the majority of the students who said their high school science courses were fun showed a significant decrease in interest in their college biology course. Of the total respondents for this question, 77% were in this group. This leads to further questions as to what was happening in these college courses that students perceived them as less fun. Fun is an important aspect of learning that contributes to college students' interest and motivation.

Slightly less than half of students agreed that they were made aware of STEM careers and they showed a significant decrease in interest in their college biology course. Slightly more than half of the students tended to disagree with the statement that during high school they were made aware of STEM careers that were available to study in college and their course interest did not change.

Students' reasons for course choice related to change in interest. These questions were asked to ascertain whether students chose biology courses because of interest or because it was required (Table 11). Appendix I contains figures that display bar charts with standard error bars for these statements.

Table 11

Comparison of Means Regarding Decision to Enroll in Biology and Course Interest

		Pre-CIS S.A./Agree		Post-CIS S.A./Agree		Pre-CIS S.D./Disagree		Post-CIS S.D./Disagree	
Category	Statement	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SD*)
The reason that I decided to register for this biology course:									
	I am interested in biology and the things that I might learn.	541	135.59 (0.70)	438	131.54 (1.12)	84	116.81 (2.13)	70	124.6 (2.62)
	I chose this course because it is a pre-requisite for applying to nursing or another health related degree program.	536	131.92 (0.76)	422	129.71 (1.16)	195	126.28 (1.35)	16	125.88 (1.82)
	I want to know how my body works.	582	133.26 (0.71)	468	130.43 (1.07)	64	124.94 (2.34)	52	122.10 (3.70)

The majority of students agreed with the statement: "I am interested in biology and the things that I might learn." Unfortunately, these students showed a significant decrease in interest from the beginning to the end of their biology course. The students that disagreed with the statement actually showed a significant increase in interest from beginning to end of the biology course. Perhaps some of these students that initially felt that they would not be interested were required to take the biology course and were pleasantly surprised and found the material engaging.

Most of the students stated that they chose biology courses because they were prerequisites for applying to nursing or another health related degree program. However, these students showed a significant decrease in interest from the beginning to the end of the semester. These results speak to relevance being an important construct of interest and motivation. The material was relevant to their career goal yet they lost interest.

The majority of students agreed with the statement that they were taking the course because they wanted to know how their body works. The students who agreed showed a significant decrease in interest in their biology course from beginning to end of the semester although they stated that they were curious about how their body works in the beginning.

Students' main motivation for their career goal and change in interest. The next section highlighted some of the significant statements for main motivation for the students' career goal and how interest changed for the individuals (Table 12). These questions related to income, job security, interest, and altruism. Appendix J contains figures that display bar charts with standard error bars for these statements.

Table 12

Comparison of Means Regarding Career Motivations and Course Interest

		Pre-CIS S.A./Agree		Post-CIS S.A./Agree		Pre-CIS S.D./Disagree		Post-CIS S.D./Disagree	
Category	Statement	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SE*)	*N*	*M* (*SD*)
My main motivation for my career goal is:									
	I want to make a lot of money.	569	129.95 (0.77)	451	127.40 (1.12)	144	131.11 (1.70)	110	133.93 (2.13)
	My interest in science.	467	134.42 (0.77)	386	130.43 (1.21)	145	120.23 (1.61)	118	121.32 (2.17)
	I think I will enjoy helping people	699	131.76 (0.66)	564	128.71 (1.00)	24	128.21 (4.35)	21	125.67 (5.24)
	Family or parental expectations	219	128.88 (1.27)	176	125.02 (1.78)	360	128.80 (0.96)	292	130.12 (1.37)
	My parents said that it would be a good choice	293	129.97 (1.05)	240	126.79 (1.60)	268	129.42 (1.15)	209	131.29 (1.53)
	Supporting my children or the children that I hope to have someday.	312	131.23 (1.06)	247	127.91 (1.55)	340	127.52 (0.99)	276	128.77 (1.41)
	My ethnic background/ culture strongly values education	358	131.75 (0.97)	285	129.12 (1.39)	225	127.98 (1.28)	180	129.34 (1.76)
	It's what I have always wanted to do.	496	133.25 (0.82)	403	129.44 (1.20)	90	125.72 (1.74)	74	129.39 (2.44)
	I think it will be easy to obtain a job.	347	132.20 (0.96)	273	128.94 (1.46)	150	128.63 (1.48)	125	129.42 (2.09)
	I want job security.	592	131.01 (0.73)	470	127.94 (1.11)	61	131.79 (2.14)	53	129.87 (3.26)

Students stated that making a lot of money was their main motivation for their career goal and they showed a significant decrease in interest from the beginning to the end of the semester. The majority of students agreed with this statement in the survey. These students were concerned with making a lot of money but were not interested in the material even though it was likely to be relevant to their careers. Those who disagreed with this statement showed a significant increase in interest in their course from beginning to end of the semester. This suggests that some students, though the smaller portion of the sample, actually enjoyed learning for self-improvement and career preparedness and they were not overly concerned with money in regard to why they chose their career goal.

Students who agreed with the statement that their main motivation for their career goal was interest in science showed a significant decrease in interest by the end of the semester. Since these students stated that they were interested at the beginning of the semester it is necessary to investigate instructor and course characteristics that might have affected this decline.

The next statement was about prospective career enjoyment. A significant decrease in interest occurred for students that agreed with the statement that their main motivation was choosing a career that would enable them to help people. Remarkably, 97% of the students were in this category. Students may want a career that is noble and helps others, however, they may not be truly prepared to take on science courses at the college level. Considering that careers that help people are often some aspect of healthcare, it can be difficult for community college students to adjust to the demands of one or more college science courses, in addition to the other responsibilities in their lives.

Nearly half of the students agreed with the statement that their main motivation for their career goal was due to family or parental expectations. Those that agreed with this statement showed a significant and marked decrease in interest.

Students that agreed with the statement that the need to support their children (or the children they will someday have) influenced their career choice showed a significant decrease in interest from the beginning to the end of the semester. As with earlier statements like perceived future income, making money, and job security, this statement may also speak to extrinsic compensation and not choosing a career where their true interests lie. Though many factors affect interest, making a career choice for enjoyment may be more important than other criteria.

Students that agreed with the statement that their career goal was affected by the fact that their ethnic background/culture strongly valued education showed a marked and significant decrease in interest during the semester. Once again, making choices based upon what others encouraged may not promote interest in the field they have chosen to study.

Those that agreed with the statement that their main motivation for their career goal was because it was what they have always wanted to do showed a significant decrease in interest, while those that disagreed with this statement did not change. This may be because the students did not have a true understanding of what these career preparation courses entailed until they enrolled in the course. Once enrolled in the course they might have realized that they were not interested in the material.

Students that agreed with the statement that their main motivation for their career was because they thought it would be easy to obtain a job significantly decreased in interest from beginning to end of the semester. These students may have chosen a career based on what they were told would be a good field to enter, but they were not necessarily interested in it.

The last statement in this category was that the main motivation for students' career goal was job security. The large majority of students agreed with this statement and there was a significant decrease in their interest. Students may have chosen a goal because they believed it was a wise choice and that they would find a job in that field, however, they were not necessarily interested in the material to acquire that degree. Allied health careers will always be necessary because people will always get sick, therefore, the process is highly competitive and students feel pressured to do well in the science courses that serve as pre-requisites. This may have impacted their overall interest.

4.3 Relationship of Instructor Characteristics to Changes in Interest, Confidence, and Motivation: Quantitative Results

There were five characteristics of instructors that were shown to have significant effects on student course interest. Adjusted means, standard errors, and confidence intervals for all of the instructor characteristics variables are shown in Table 13.

Table 13
Descriptive Statistics for Instructor Characteristics and Course Interest

Subgroups	*N*	*M (SE)*	95% CI
Instructor has an education degree or certification	242	0.53 (1.23)	[-1.06, 3.66]
Instructor does not have an education degree or certification	397	-5.35 (0.95)	[-6,67, 2.99]
Full-time instructor	292	-6.14 (1.11)	[-8.33, -3.96]
Part-time instructor	347	-0.59 (1.02)	[-2.59, 1.41]
Instructor has taught high school	307	-0.65 (1.07)	[-2.75, 1.46]
Instructor has not taught high school	332	-5.42 (1.03)	[-7.44, -3.39]
Instructor has a doctoral degree	316	-4.89 (1.07)	[-6.98, -2.79]
Instructor does not have a doctoral degree	323	-1.33 (1.07)	[-3.44, 0.79]
Instructor has taken education courses	364	-1.64 (0.99)	[-3.58, 0.31]
Instructor has not taken education courses	275	-5.09 (1.14)	[-7.33, -2.86]
Male instructors	324	-3.71 (1.05)	[-5.77, -1.65]
Female instructors	315	-2.52 (1.07)	[-4.62, -0.43]
Instructor same gender as student	279	-2.89 (1.14)	[-5.12, -0.66]
Instructor opposite gender as student	353	-3.21 (1.01)	[-5.19, -1.23]

When students had an instructor who possessed an education degree or certification they showed a significant increase in interest ($M = 0.53$); those whose instructor did not have an education degree nor certification showed a mean decrease in interest in their biology course ($M = -5.35$), where F (1, 636) = 13.91, $p < .001$, $d = 0.29$, with small/medium effect. In a paired samples *t*-test for the students that were taught by an instructor that did not have an education degree nor certification there was a significant decrease in interest from pre- (*M*=127.94, *SD*=17.77) to post- (*M*=123.48, *SD*=23.94); $t(395)=-4.47$, $p < .001$, $d=0.21$, which is a small effect. Students who took a class with a full-time instructor had a significantly greater decrease in interest in their biology course (*M* = -6.14), and students taught by part-time instructors showed an increase in interest over the course of the semester (*M* = -0.59) with a small/medium effect size of 0.29. In a paired samples *t*-test for the students being taught by a full-time instructor there was a significant decrease in interest from pre- (*M*=126.82, *SD*=17.19) to post- (*M*=122.00, *SD*=22.88); $t(289)=-4.17$, $p < .001$, $d=0.24$, a small effect.

Similar effects were observed when students were enrolled in a class of an instructor that had taught high school. Students showed a slight decrease in interest over the course of the semester (*M* = -0.65), but the students in a class where the instructor has never taught high school showed a significantly greater decrease in interest (*M* = -5.42), $F\ (1, 636) = 10.26$, $p < .01$, $d = 0.26$. In a paired samples *t*-test for the students being taught by an instructor that never taught high school there was a significant decrease in interest from pre- (*M*=130.14, *SD*=17.58) to post- (*M*=124.99, *SD*=24.61); $t(331)=-4.83$, $p < .001$, $d=0.24$. Students enrolled in a class taught by an instructor who possessed a doctoral degree showed a significantly greater decrease in interest (*M* = -4.89) than students that were taught by instructors who did not possess a doctorate (*M* = -1.33), $F\ (1, 636) = 5.36$, $p < .05$, $d = 0.18$, a small effect. In a paired samples *t*-test for the students being taught by an instructor without a doctoral degree there was a significant decrease in interest from pre- (*M*=135.90, *SD*=16.71) to post- (*M*=133.63, *SD*=22.42); $t(314)=-2.14$, $p < .05$, $d=0.11$, which is a negligible effect. For the students that were taught by an instructor with a doctoral degree there was a significant decrease in interest in the paired samples *t*-test from pre- (*M*=123.37, *SD*=23.71) to post- (*M*=127.17, *SD*=17.90); $t(320)=-3.47$, $p < .01$.

When students enrolled in classes where the instructor had never taken education courses, their interest in the biology course decreased significantly more than those students in a class being taught by an instructor that had taken education courses (*M* = -5.09 and -1.64 respectively), $F\ (1, 636) = 5.22$, $p < .05$, $d = 0.18$. In a paired samples *t*-test for the students taught by an instructor who never took education courses there was a significant decrease in interest from pre- (*M*=129.39, *SD*=17.42) to post- (*M*=124.72, *SD*=24.31); $t(274)=-3.97$, $p < .001$, $d=0.22$. The ANCOVA results for the five significant instructor characteristics are in Table 14.

Table 14
ANCOVA for Instructor Characteristics and Course Interest

Variable(s)	*df*	*F*	Significance	Cohen's *d* (η_P^2)
Instructor has a degree or certification in education	636	13.91	.000***	0.29 (0.021)
Instructor status: full-time/part-time	636	13.17	.000***	0.29 (0.020)
Instructor has taught high school	636	10.26	.001**	0.26 (0.016)
Instructor has a doctoral degree	636	5.36	.021*	0.18 (0.008)
Instructor has taken education courses	636	5.22	.023*	0.18 (0.008)

*$p < .05$, **$p < .01$, ***$p < .001$

4.4 Relationship of Course Characteristics to Changes in Interest, Confidence, and Motivation: Quantitative Results

The three course characteristics that were significant were: whether the students were assigned a library research project during the course, attrition rate of the course, and course type. The four categories of courses that were surveyed in this study: electives, majors, service, and programmatic courses. The programmatic category was collapsed into the service category in order for these variables to meet the assumption of equality of variance for the ANCOVA and yielded significant results. This was a logical grouping because the service courses were ultimately a requirement of the program that a student was attempting to enter, whereas programmatic refers to a course required by a program that the student was already accepted. Table 15 shows population size, the estimated marginal means, and standard error of the four course categories as well as other course related variables.

Table 15
Descriptive Statistics for Course Characteristics and Course Interest

Subgroups	*N*	*M (SE)*	95% CI
Attrition rate ≥10% for the course	338	-5.69 (1.09)	[-7.82, -3.56]
Less than 10% attrition	299	-0.76 (1.02)	[-2.76, 1.25]
Students performed a library research project during the course	156	0.27 (1.51)	[-2.70, 3.24]
Students did not perform library research during the course	474	-4.04 (0.87)	[-5.742, -2.34]
Elective courses	220	-1.77 (1.28)	[-4.27, 0.74]
Majors courses	124	-7.39 (1.69)	[-10.72, -4.07]
Service and programmatic courses	293	-2.34 (1.10)	[-4.51, -0.18]
Day class	479	-3.26 (0.86)	[-4.96, -1.56]
Evening class	160	-2.73 (1.50)	[-5.66, 0.21]
Weekday class	575	-3.12 (0.79)	[-4.68, 1.57]
Weekend class	64	-3.14 (2.39)	[-7.83, 1.56]
Student performed a research project that was not a requirement	107	-2.08 (1.83)	[-4.57, -1.29]
Students did not perform a science research project	514	-2.93 (0.83)	[-5.67, 1.52]

Attrition rate of the course was associated with students' change in interest. When students were in a class that had 10% or greater attrition they had a significantly greater decrease in interest than students in a class that had less than 10% attrition. High attrition rates could result from the instructor's teaching style, attitude or level of support. Attrition rate may have affected the remaining students' interest and attitude in the course. If they were doing well, their confidence may have been boosted. Some may have questioned their own interest and motivation if they witnessed many other students not doing well and dropping out. The difference in interest between students in a higher attrition rate class was -5.69 compared to those in a lower attrition rate class which was -0.76, $F(1, 634) = 10.93$, $p < .01$, $d = 0.26$. In a paired samples *t*-test for the students in a course where the attrition rate was 10% or greater there was a significant decrease in interest from pre- (*M*=130.37, *SD*=16.62) to post- (*M*=124.92, *SD*=24.04); $t(298)=-4.90$, $p < .001$, $d=0.26$.

Students who had a library research project requirement in their biology courses showed a significant increase in student interest compared to those that did not $F(1, 627) = 6.09$, $p < .05$, $d = 0.20$ (small effect). In a paired samples *t*-test for the students in a course where there was not a library assignment there was a significant decrease in interest from pre- (*M*=130.62, *SD*=17.78) to post- (*M*=126.84, *SD*=23.93); $t(471)=-4.27$, $p < .001$, $d=0.18$. Students taking a class with a library research project assigned showed an increased interest in their biology course ($M = 0.28$) and students that did not showed a decrease in interest over the course of the semester ($M = -4.04$). The biology majors showed the greatest decrease in interest from the beginning to the end of the semester ($M = -7.39$). In a paired samples *t*-test for the students in a biology majors course there was a significant decrease in interest from pre- (*M*=128.94, *SD*=18.02) to post- (*M*=122.06, *SD*=25.80); $t(123)=-4.24$, $p < .001$, $d=0.31$, a small/medium effect size. The combined service and programmatic categories ($M = -2.34$) showed a significant decrease interest in the ANCOVA. In a paired samples *t*-test for the students in a service or programmatic biology course there was a significant decrease in interest from pre- (*M*=134.76, *SD*=16.32) to post- (*M*=131.73, *SD*=23.17); $t(294)=-2.75$, $p < .01$, $d=0.15$. Of the three categories, the students taking electives had the smallest decrease in interest ($M = -1.77$). The ANCOVA for the three course type groupings yielded $F(2, 635) = 4.01$, $p < .05$, $d = 0.22$. The ANCOVAs that yielded significant results for course characteristics are listed in Table 16.

Table 16
ANCOVA for Course Characteristics and Course Interest

Variable(s)	*df*	*F*	Significance	Cohen's d (η_P^2)
Attrition rate ≥10%/ less than 10%	634	10.93	.001**	0.26 (0.017)
Library research project during course	627	6.09	.014*	0.20 (0.010)
Course type: elective/major/service	635	4.01	.019*	0.22 (0.012)

*$p < .05$, **$p < .01$

Students that were enrolled in evening and weekend classes showed less of a decrease in interest over the course of the semester. Biology majors in their first introductory course showed the greatest decrease in interest when looking at all the courses surveyed. Biology majors in the second and third course in their sequence showed an increase in interest. Students enrolled in the first two of the service courses also showed decreases in interest. Anatomy and Physiology I (7) and II (8) were taken by mainly by students hoping to apply to an allied health career, predominantly nursing, and these courses had a high attrition rate. The students enrolled in the programmatic courses showed increases in interest in their biology course. These students probably showed an increase in interest in their course because the information being learned was relevant to their specific program. Table 17 shows the descriptive statistics for the students who completed the pre- and post-CIS in each course.

Table 17
Descriptive Statistics for Change in Interest by Course Type

Course number	Sections *N*	Instructor *N*	Student *N*	*M* (SE)*	95% CI
Elective					
1	9	6	132	0.72 (1.60)	[-2.46, 3.90]
2	3	3	50	-5.40 (3.49)	[-10.56, -0.24]
3	2	1	36	-0.97 (3.08)	[-7.06, 5.11]
Majors					
4	4	3	69	-13.94 (2.03)	[-18.34, -9.55]
5	2	2	40	1.05 (2.38)	[-4.72, 6.82]
6	1	1	15	4.47 (4.40)	[-4.96, 13.89]
Service					
7	7	6	93	-6.49 (1.89)	[-10.28, -2.71]
8	5	4	73	-6.22 (2.50)	[-10.49, -1.95]
9	6	4	85	1.01 (2.01)	[-4.97, 2.95]
Programmatic					
10	1	1	10	15.00 (5.60)	[3.46, 26.54]
11	2	1	34	2.97 (1.64)	[-3.29, 9.23]

Several variables showed significance through ANCOVA, however all of them had small to small/medium effect sizes. The final step in quantitative analysis was to perform binary logistic regression in order to elucidate what combination of the above variables best-predicted student interest in their biology course.

4.5 Binary Logistic Regression for Prediction of Interest

A binary logistic regression analysis was performed to ascertain which combination of variables in each of the three categories (student, instructor, and course characteristics) could increase student interest in their biology courses. Binary refers to the assigning one value to students that decreased or did not change in interest, while another value is assigned to the students that showed an increase in interest. The logistic regression model was statistically significant χ^2 (22) = 43.135, $p < .01$ and the null hypothesis was rejected. The model explained 10.0% (Nagelkerke R^2) the variance in student interest and correctly classified 64.0% of the overall cases, 71.1% of the cases where student interest decreased and 55.8% of the cases where student interest increased. This is an improvement over the correct classifications of the null model of 53.9%. The Hosmer and Lemeshow Goodness-of-Fit Test indicated that the logistic model was a good fit because $p > .05$ and therefore the model's estimate fits the data at an acceptable level; the Hosmer and Lemeshow χ^2 (8) =15.352, $p = .053$.

The model showed six significant variables that predicted course interest: 1) having instructors who taught part-time, 2) having instructors who taught high school, 3) student career goal, 4) student age, 5) whether the course was during the day or the evening, and 6) student previous degree status. The greatest odds ratio, exp *(β),* difference was seen when students were taught by a part-time rather than a full-time instructor; their interest was 2.05 times likely to increase. The second greatest odds ratio in this model was seen when students were taught by an instructor who had high school teaching experience; student interest was likely to double in this scenario. Students that had STEM-related career goals were 1.86 times less likely to be interested in their biology course in comparison to those that did not have a STEM-related career goal. Students that were 25 and older were 1.71 times more likely to have an increase in interest during their biology course compared to the younger age group. When students were enrolled in an evening class they were 1.71 times more likely to be interested in their biology course than daytime students. Students that held previous degrees were 1.70 times as likely to show an increase in interest in their biology courses.

These results suggest target groups in need of intervention to increase student interest and motivation to study science (Table 18). Several student groups needed to be targeted: younger students and those who did not have much experience in higher education need special attention. STEM majors needed special attention to retain their interest in order to help them stay motivated and persist. Daytime students might benefit from special programs or varied teaching techniques to keep them interested and motivated at the community college. Professional development may be necessary to help instructors learn how to retain or increase the interest of the students.

Table 18
Logistic Regression Model of Characteristics that Predict Course Interest

Variables	*β (SE)*	*Wald*	Odds Ratio exp (*β*)	95% CI for Odds Ratio
Student characteristics				
STEM-related career goal	-0.622 (0.29)*	4.586	0.54	[0.30, 0.95]
Previous degree holders	-0.533 (0.25)*	4.426	0.59	[0.36, 0.96]
Age 18-24, 25 and older	0.535 (0.27)*	4.021	1.71	[1.01, 2.88]
Student gender	0.181 (0.20)	0.832	1.20	[0.81, 1.77]
Country of origin	0.003 (0.27)	0.000	1.00	[0.60, 1.69]
Ethnicity	-0.037 (0.07)	0.321	0.96	[0.85, 1.10]
Full-time/part-time student	0.085 (0.23)	0.140	1.09	[0.70, 1.70]
Parental status	0.427 (0.34)	1.561	1.53	[0.78, 3.00]
Student has at least one job outside of home	-0.098 (0.30)	0.111	0.91	[0.51, 1.62]
Student states they study enough/not	-0.077 (0.19)	0.167	0.93	[0.64, 1.34]
Instructor characteristics				
Full-time/part-time instructor	-0.718 (0.31)*	5.284	0.49	[0.27, 0.90]
Instructor has taught high school	0.685 (0.33)*	4.348	1.98	[1.04, 3.78]
Instructor has taken education courses	-0.292 (0.34)	0.754	0.75	[0.39, 1.44]
Instructor has education degree	0.234 (0.37)	0.404	1.26	[0.61, 2.60]
Instructor has a doctorate	0.158 (0.29)	0.300	1.17	[0.67, 2.06]
Instructor gender	0.014 (0.21)	0.004	1.01	[0.67, 1.53]
Instructor has a certification in education	0.030 (0.40)	0.006	1.03	[0.47, 2.27]
Course characteristics				
Daytime/evening course	0.535 (0.27)*	4.050	1.71	[1.01, 2.87]
Course category	-0.108 (0.17)	0.393	0.90	[0.64, 1.26]
Weekday/weekend course	0.662 (0.37)	3.203	1.94	[0.94, 4.00]
Research project/not	-0.207 (0.24)	0.723	0.81	[0.51, 1.31]
Library research project/not	0.264 (0.23)	1.35	1.30	[0.83, 2.04]

*$p < .05$

4.6 Factors that Affect Course Interest: Qualitative Data Analysis

Qualitative data were collected from 12 students selected by purposeful sampling with maximum variation among age, gender, parental status, country of origin, ethnicity, part-time/full-time status, employment status, major and career goals. The demographics of the interviewees were consistent with the overall student population and sample. The interviewee demographics are listed in Table 19. The themes that emerged from the open and axial coding were intrinsic factors and extrinsic factors that affected the students' motivation to study science; factors were categorized into one or more of the four constructs of interest: attention, relevance, confidence and satisfaction. This information is pertinent as it provides context and nuance for the quantitative findings. Connections between the quantitative and qualitative data are explored in the section that follows.

Table 19
Interview Participant Demographics

Student	Age	M/F	Parent	Country of origin	Ethnicity	FT/PT	# of Jobs	Hold a degree?	Major	Career goal	Class type*
Felicia	20	F	No	U.S.	Hispanic	PT	1	No	Lib Arts	Nurse	S
Krista	26	F	Yes	U.S.	Hispanic	PT	1	No	Lib Arts	Neonatal nurse	S
Rebecca	36	F	Yes	Afghanistan	Asian	FT	1	No	Lib Arts	Nurse	S
James	22	M	No	U.S.	White	PT	4	Yes, BS	Non-Matric	Phys. Assistant	S
Sandy	25	F	No	U.S.	Black	PT	1	Yes, BS	Biology	Optometrist	S
Kenny	20	M	No	Peru	Hispanic	FT	1	No	Math	Occup. Therapy	S
Eli	19	M	No	U.S.	White	FT	1	No	Lib Arts	Biologist	E
Logan	25	M	No	U.S.	Black	FT	1	No	Biology	Pharmacist	M
Laura	18	F	No	U.S.	White	FT	1	No	Biology	Doctor	M
Marjorie	19	F	No	U.S.	White	FT	1	No	Lib Arts	Veterinarian	M
Maya	22	F	No	U.S.	White	PT	1	No	Lib Arts	Physical Therapist	M
Brian	19	M	No	U.S	Black	FT	1	No	Biology	Doctor	M, S

*S = Service course, E = Elective course, M = Majors course

Qualitative data related to theoretical framework. The open, axial, and thematic codes were consistent with the theoretical framework of the study and the quantitative findings. The open and axial codes that fell into the four constructs of the course interest were a mixture of both intrinsic and extrinsic factors for motivation, which were the major themes that emerged from the qualitative portion of the study. Students that had a malleable or growth mindset were more capable of moving from the traditional pedagogical model of teaching towards the andragogical model of learning. A combination of intrinsic and extrinsic factors helped promote each of the four factors for interest in science. The open codes were occurrences in students' lives and attributes of their education that affected their interest and therefore motivation to study science. A new model was then derived from the theoretical framework, the constructs of the instrument, and the factors that emerged from the qualitative data.

Interest is one construct that affects motivation, and there are four constructs of the instrument that contribute to a student's course interest: attention, relevance, confidence and satisfaction. There was a significant decrease in relevance, confidence, and satisfaction from pre- to post-CIS when paired samples *t*-tests were performed. Attention was not significantly changed. These results showed that not only did overall interest significantly decrease, but three of the individual constructs of interest decreased by the end of the semester. Questions regarding change in attention were included in the interview script because the qualitative data were collected between the pre- and post-survey administration.

The fewest codes were classified in the relevance construct. Several codes (or factors) were classified in the other three constructs (attention, confidence and satisfaction) and some of the codes were related to more than one construct since the classification of the factors was not linear and there was some overlap. Intrinsic and extrinsic factors derived during open coding related to the four constructs and they contributed to students moving from passive to experiential learning, dependent to self-directed learning, subject-centered to performance-centered learning and curriculum-focused to real world application learning. Upon examining these factors it was apparent that many intrinsic factors affected the extrinsic factors. The relationship was also reciprocal – an extrinsic factor such as a teacher can make science interesting, more understandable, and fun, which were some of the top intrinsic factors leading to motivation to study science. Following the salient points, subsections of the qualitative data that impact student motivation are organized by the four constructs of interest.

Salient points from the interviews. Some codes appeared in all twelve interviews. All students mentioned that their instructors' attitudes towards the class affected them in some way; half of those individuals stated that some aspect of the instructors' attitudes had a negative impact on them. However, all students stated they appreciated the support of their current instructors and they affected their motivation to study science. Additionally, all of the interviewees stated that science can be fun, which had something to do with the way the instructor taught the course. All interviewees also believed that mathematics was a factor in their interest in their science courses, with two-thirds of them stating that mathematics had a negative impact on their view of science. For some students this was a fixed mindset. However, these students were enrolled in biology courses by their choosing, so perhaps some possessed a growth mindset regarding science, that is, with effort they could improve their achievement in science even if they felt their mathematics skills were an impediment. The factors that contributed to the motivation of at least 50% of the interviewees are listed in Table 20.

Table 20
Frequency of Codes in Interview Responses

Open code	**Axial code**	**Theme**	**% of interviews appears**
Fun	Personal experiences motivate	Intrinsic	100.0
Math is a factor	Pride/self-esteem	Intrinsic	100.0
Instructor's attitude affects me	Academic support structures	Extrinsic	100.0
Supportive instructor	Academic support structures	Extrinsic	100.0
Higher goals than community college	Pride/self-esteem	Intrinsic	91.7
Improvement from last generation is important	Personal experiences motivate	Intrinsic	91.7
Instructor tries to help us understand/is interesting	Academic support structures	Extrinsic	91.7
Support of family	External support leads to mobility	Extrinsic	91.7
Passionate science teacher in past	Academic support structures	Extrinsic	83.3
Education as a positional advantage	External support leads to mobility	Extrinsic	83.3
Enjoys academic challenge	Personal experiences motivate	Intrinsic	83.3
Happiness is more important than money	Personal experiences motivate	Intrinsic	83.3
Have a clear career goal	Personal experiences motivate	Intrinsic	83.3

High school teacher	Academic support structures	Extrinsic	83.3
Interesting	Personal experiences motivate	Intrinsic	83.3
Parents allow own choices	External support leads to mobility	Extrinsic	83.3
Liking science	Personal experiences motivate	Intrinsic	75.0
Makes sense to me/understand material	Pride/self-esteem	Intrinsic	75.0
Money is an advantage for others	External support leads to mobility	Extrinsic	75.0
Struggle with the material	Academic support structures	Extrinsic	75.0
Becoming an adult/realize responsibility	Pride/self-esteem	Intrinsic	66.7
Small class size/personal attention from instructor	Academic support structures	Extrinsic	66.7
Ability to prioritize	Pride/self-esteem	Intrinsic	58.3
Advisor/someone discouraged me regarding science	Academic support structures	Extrinsic	58.3
Enjoy helping others	Altruism	Intrinsic	58.3
Information learned is goal-oriented	Academic support structures	Extrinsic	58.3
Middle school teacher	Academic support structures	Extrinsic	58.3
Overcoming academic obstacles of the past	Pride/self-esteem	Intrinsic	58.3
Overcoming personal obstacles	Pride/self-esteem	Intrinsic	58.3
Personal experiences affect choices	Personal motivation	Intrinsic	58.3
Instructor has great content knowledge	Academic support structures	Extrinsic	58.3
Science is hard	Pride/self-esteem	Intrinsic	58.3
Appreciates opportunities	Pride/self-esteem	Intrinsic	50.0
Community college was not first choice	Pride/self-esteem	Intrinsic	50.0
Getting good grades now	Pride/self-esteem	Intrinsic	50.0
Got good grades in the past	Pride/self-esteem	Intrinsic	50.0
Not afraid to ask questions	Pride/self-esteem	Intrinsic	50.0
Overcoming cultural obstacles	Childhood struggles	Intrinsic	50.0
Parents/grandparents are pleased	Pride/self-esteem	Intrinsic	50.0
Partner encourages	External support leads to mobility	Extrinsic	50.0
Counselors/teachers not making students STEM aware	Academic support structures	Extrinsic	50.0
Work is a distraction from academics	External support leads to mobility	Extrinsic	50.0

Attention. Attention can be voluntary or selective and has three distinct but interactive neural systems that control arousal, activation and effort (Pribram & McGuinness, 1975). Attention is required for learning and motivation; a student must be directed toward the appropriate stimuli and that direction must be sustained (Keller, 1987). Attention, in the context of this study, referred to students' propensity to direct their focus to what was being taught in the course because it was interesting to them. Although the majority of the factors that affected students' attention were categorized as extrinsic, some factors categorized as intrinsic also contributed to attention. Some examples of the most commonly occurring intrinsic factors that impacted attention were: having higher goals than community college, enjoying an academic challenge, having fun, and becoming an adult or realizing responsibilities. Most of the extrinsic factors involved another individual affecting the student in some way; one such example was having a passionate teacher in the past. Most students stated that their instructors' attitudes, personal attention, and small class sizes affected them in positive ways. Interactions with other students were also important. Many students expressed that work was a distraction from their studies (one of the few extrinsic factors that was not directly related to another person), which affected them by directing their attention towards other things for a period of time and could decrease their studying.

Most students emphasized the importance of the way the instructor taught in gaining their attention. Sandy, a degree holder returning to school to become an optometrist, stated:

> …it really depends upon the professor. It really does. And I know a lot of individuals say that's not always the case, but for me it really is the case. It depends on the professor. If you're able to present it in an interesting way, then you've got my attention, then I'm gonna sit there and I'm gonna listen to you, and I'll make my comments and ask questions… I absolutely love the course, despite the fact that I am doing mediocre, that is my favorite course, and I can say that with such confidence because she actually draws me into it. I love commenting, I love asking questions, I love the way she presents the material. She actually makes it very active and interesting.

Here was a case where the student's achievement did not overshadow her interest for the course. She was enjoying it and was attentive even though she was not getting the grades she desired.

Kenny was a mathematics major, one of the few students who did not say mathematics had a negative impact on his view of science. He touched upon many frequently mentioned attention-related factors during his interview. Pre-college experiences and influences helped build his character and sense of responsibility, and shaped how he viewed the world. Activation is "psychological readiness to respond" (Pribram & McGuinness, 1975, p. 116) and effort is required to follow through with goal-directed actions. Some students shared how they capitalized on opportunities based on attention being an important factor of motivation. Kenny spoke about one teacher who helped to shape the direction of his life:

> In Peru. Yeah. I remember one of my teachers. He told me just become whoever you want to be. Just – if you wanna be a doctor, you wanna be a carpenter, just be it. Don't think about it twice. Don't think about it three times. You wanna be that, you love it, just do it. And made me who I am, you know? He made me understand that if I have to do homework, I have to do it, and he made me be whoever, you know, because he showed me that you have to be responsible. You have to do things and you have to work hard for you to become who you are.

He learned to follow his passion and it was clear from the tone of his interview that he believed in himself. He was influenced by his teacher in his belief that everyone needs to take responsibility for his own actions and choices, which ultimately affects happiness. In fact, eight of the interviewees referenced recognizing responsibilities as an important aspect of their motivation once they became adults. Having a sense of the need to take responsibility is an intrinsic factor that was cultivated by an extrinsic factor somewhere in the students' past experiences.

Kenny learned about responsibility from his teacher, his experiences in high school, and the changes he encountered once he entered college. Student background factors are relevant to the formation of student interest and motivation earlier in their lives. Attention is an important component of those constructs, which are essential for persistence as a student transitions into college, a non-compulsory experience. When asked about high school he said that high school really did not prepare him for college:

> High school is pretty lenient, you know? High school is like you being with your mom and your mom is crossing the street holding your hand. College is when you are becoming adult and you're just hit with responsibilities: work, gotta find food, you gotta find a place to sleep, a place to live and that's what college is about. It's – you're on your own. They don't even send your grades to your mom and dad because you are old enough to actually make decisions about yourself. That's why I took AP stats in high school and they said it was going to be the same. It's really not.

He enjoyed academic challenges and knew that his choices had a profound effect on his future. He set his sights higher than community college. His goal was to earn admission into an occupational therapy program at a four-year college, not the occupational therapy assistant program at the community college. During his junior year in high school he was accepted into a program that exposed him to the different career possibilities in the medical field. This type of program seemed to be an exception, as half of the students interviewed felt that their guidance counselors and teachers did not adequately inform them about STEM careers. Kenny realized that there were other health-related opportunities besides being a doctor or a nurse. Because of this program he realized that he was interested in becoming an occupational therapist.

He and his friend talked about what it might be like if they would become doctors together. If they did apply to medical school he would have already taken many of the classes that he would need in order to be accepted. The relevance of the material to possibilities other than occupational therapy was another reason that his current science courses retained his attention.

> I mean, they [doctors] have no life… But it's still in the back of my head. It's still that-- I'm thinking. Like I said, it's like this crazy dream that we both have of going to medical school together, but it's something that is gonna take a lotta work, it's gonna take a lotta time, which is half the challenge. If we can make it, it would be great. I mean, I come from far, far away from here, and it's just the opposite 'cause we just see it and we just have to accomplish it. That's pretty much it.

He was a student with a very strong work ethic, and in addition to school and work he was a leader in the student government association. Like many of the students in this sample, he worked in addition to being a full-time student: "I used to work a lot, so, like, 40, 45 hours throughout the week plus school, and I went down in my grades with micro[biology]." Half of the interviewees stated that their job was a distraction from their academics, which affected their attention and therefore motivation.

He discussed one of the other major themes in these qualitative findings: the contribution of personal consideration and care from the instructor. Eight of the twelve students interviewed felt that this type of external validation was essential to their motivation. It was important for students to know they had access to their instructor for one-on-one time and it made them feel more at ease when dealing with difficult coursework. When asked if he felt that the community college gave him more attention and helped facilitate learning better than a four-year school, he said:

> They do because they know your name. You can go to a professor and talk to them and sit down with them, and you can use that time. In other schools, for example, [a local four-year university] – which my friend is in – he says it's a whole, like, an audience of just learning and when he wants to ask questions, it really doesn't work out that well. He knows what [the community college] is like and what [a local four-year university] is right now. It's a lotta work. It's mostly you teaching yourself in what to do. It's just the professor telling you, showing you the path. You just gotta follow it. But here at [the community college], it's – if you wanna have one-on–one time, like, with your professor, he will do it. My math professor does that. Every time he could be here without even actually [having to be] here, but he helps you out; and, I guess, I like this school, I mean.

Rebecca, a married mother from Afghanistan who aspired to become a nurse, was asked if she felt that her instructor had an effect on her confidence and interest. She spoke about how important her instructor was in maintaining her attention:

> Yeah, like if I don't understand something I can ask it over and over and over and he explains it. Even after class he stays and reviews with the class. Like last time, everyone stayed and he did like an hour over [the regularly scheduled class time].

She affirmed that his openness to help her and the rest of the students kept her interested. Most of the interviewees appreciated the nurturing they received from their college instructors because it contributed to their attention in the course. Maya, an aspiring physical therapist, stated that she didn't think that personalized connections to the instructors and college staff had anything to do with community college as opposed to four-year college:

> If you find that professor that you have a connection with, they'll be able to assist you. You know, because even at [a neighboring four-year college] they would try to help you, but like, if you don't ask for it, then no one is going to give it to you. So, it's like, that's kind of where I went wrong. I never asked anything. Even for financial aid, you know, it's kind of like if you don't ask for it, but I guess [this community college] is so big that it's like they can't be on your back. They can't be on top of your back like, 'Oh, are you going to go [fill out your paperwork]?' And even the same goes for [the neighboring four-year college she attended], because when I left they never contacted me [to find out why I was no longer there].

Personal contact and interactions, and not just with regard to academics, were very important to some students in order to retain their course attention and persistence. Personal attention also seemed to be fundamental to course satisfaction as discussed in a later section.

The participants discussed how fun course activities increased their attention. Eli, a 19-year old taking the course as an elective, spoke of how much fun he had performing dissections and how he perceived his classmates were reacting to his excitement:

> We did some dissections in the marine biology class that I have now. And people were honestly terrified at my enthusiasm and my interest in cutting these things open and figuring out how they worked. I honestly probably acted like a five-year-old child. I have these goggles with magnifying glasses on them that I use for things like this. So I'm basically just sticking my head inside of a shark to use a magnifying glass to see what the organs look like up close. And everyone's just staring at me like: 'What is this kid doing?' And I'm just like inside of a shark. Definitely I love science. It's fun. It's entertaining. I love when you figure things out.

The active learning of dissection captivated him and kept his attention. He was extremely excited to have this fun activity and viewed it as a unique opportunity. In reference to the earlier definition of attention, this activity caused arousal, therefore garnering his attention. His enjoyment of learning and interest was evident. Laboratory work and research projects also provided relevance to the coursework, which helped to retain student attention.

All twelve of the students interviewed stated that when science was fun it helped keep them interested and motivated. Krista, an aspiring neonatal nurse, spoke about engaging aspects of study groups, which brought her satisfaction.

> I like learning about how cells work in our body and all the different kinds of cells. That was pretty fun. I have to draw diagrams and there like little pictures and stick figures. That was fun. I learned about the bones and the muscles in my class. I like that. I like to be able – my mom's like, 'Oh this hurts.' I can name the bone and the muscle. So, that's fun to me to learn how everything fits together. That's fun for me. It's like a puzzle… if I am bored, I won't read nothin'. I won't try to study. So, I try to keep it as fun as possible. I have study groups with my friends, and we try to make it fun and we'll go around and everyone has to ask a question. We'll joke about it. We'll stand up and put stickers on ourselves, just trying to make things fun. Yeah.

Working with a group of friends was an important aspect of making studying fun for her. However, some students sometimes found it challenging to make connections with others in part due to community colleges being comprised of commuters. Logan, who planned to study pharmacy, stated that it was much easier for him to form study groups when he was living on campus at the college he previously attended. When students made the effort, bonded with other students in their classes, and formed study groups, it became another support structure that helped to retain their attention. In high school Logan worked on a group research project and he stated that it helped increase his interest:

> If you could choose the project or if you could pick it out from like a large book or whatever it is, like whatever you are interested in, it will probably help you out a lot, like you'll –like yeah, this is interesting, I want to learn about it, learn about it…

He stated that he went along with the group's choice for the project even though he wanted them to do something else. Nevertheless, he valued the experience.

Logan also spoke about his extracurricular demands like sports and work affecting his attention to his coursework after he mentioned that he was taking 12 credits:

> Well, like I play basketball, and I work, so it's like when I'm – like after school I got – before school I go to work, then I come to school, then I go to practice, then I come home and sometimes I am too tired to study. Sometimes I'll try my best to study, but I study for an hour and a half, not enough, and just pass out.

Like many community college students, Logan worked a full-time job (36.5 hours per week) in addition to being enrolled full-time. But he was also on the college basketball team:

> Yeah, I'm on the team but I haven't gone because – well, financial reasons, I haven't been practicing with them, I got more hours at work and I started working at night so that I can pay off the final tuition bill so that I can register for next semester, I still haven't done that yet.

Ironically, Logan's attention to his coursework suffered because he could not afford to pay past bills without taking on a second job at night. He explained that the following semester, if he could register, he would not play basketball and would only take two classes because he still had to work full-time. He explained that if he did not work: "I'm not going to make enough money to pay for anything. I'm 25 now, so I have to pay for everything myself, and it's not any easier." His financial aid was minimal and covered less than half of his academic expenses.

Interestingly, this topic arose with Logan when asked how he felt about mathematics in relation to his science courses. He said he "despised it" because:

> Because it's – well, simple math from let's say like addition to algebra and geometry, that's fine, but then you get into calculus, and calculus just – I could do it if that's the only thing I have to focus on. If I have to focus on more things, I'm not going to be able to do it. I just can't wrap my head around it, I just can't.

Logan's other responsibilities detracted from his ability to put enough effort into learning calculus. He also spoke more about his age:

> Well, all through high school, from middle to high school, I never really had to study… But as the years got on, it's just -- I guess I have to study now and I don't have good study habits, so it's kind of hard.

When asked if it was getting harder because the subject is harder he said:

> No, I think it is because I am getting older and more stuff I have to do. Because when I was younger, I didn't have a lot to do, so, I didn't have a lot to think about. Now I have more things to think about, I have to think about my future, I have to think about my job, money, my car not breaking down on me, basketball.

More responsibilities come with age and so interest and motivation might have been higher with older students because they realized their time was limited and they should be focused on the end goal of their community college education.

Laura, an 18-year old who planned to become a doctor, discussed money in relation to attention in her biology course and the fact that attending community college was not her first choice. She stated:

> Well, [this community college] wasn't my first choice, obviously. I'd always wanted to go away to college. That was like my dream, to just get away and experience it. I didn't want to stay at home at all, so I didn't apply anywhere [in this area]. I just wanted to get out of here. And then the money situation and the way things worked out, [this community college] was just the best option for me. So I enrolled. And because I graduated with so many AP [advanced placement] credits in like English and all those things, as many APs as possible, I didn't think [this community college] was a good idea because I'm not going to be – like I already had a lot of the classes that I needed so I'm not going to be here very long… But it really worked out. It worked out pretty well because now I have a job that I can actually make money to save up and go away. And, I've talked to counselors and they're able to help me get into the schools that I want to get into.

Laura then explained how this story related to how she felt about her biology course:

> Like the bio class that I'm taking right now, it's basically the same thing I took last year, so that kind of had me annoyed because I am not really learning anything new. Like when I already know something like, I don't pay attention. So like this semester it's like I'm not paying attention as much… I feel like I want to learn more, and I feel like I'm not getting that really as much here as I would've hoped I would have gotten in college. But I don't know if that's just because I have already learned a lot so I feel like I am taking a step back, or is it just because like it's what he [the instructor] wants us to know.

When asked if she felt as though the community college courses changed her career goal of medicine, she stated:

> So-so again, too. Like I want to be a doctor, but like not if it's just going to be the same stuff over, and over, and over again. You know? ...I keep going back and forth. I've been thinking like nursing now because I don't want to keep going to school if I am going to be bored. You know? So I'm not sure.

Laura's circumstances played a role in her attention to her biology course and a major part was financial. She became unsure of her career goal because she was bored in her community college biology course due to what she had previously learned in her AP Biology course.

In this section many factors were highlighted that contributed to improving a student's attention. However, a prominent deterrent from attention was the extended amount of time spent on work rather than studies. Personal attention from the college instructor, passionate teachers in the past that helped instill values about becoming a responsible adult, and camaraderie with fellow classmates were external support structures that contributed to students' attention. Some of these factors were also categorized in the relevance and satisfaction constructs on interest.

Confidence. Confidence is described as "expectancy for success" that can be attributed to abilities and effort, which can lead to persistence and accomplishment (Keller, 1987, p. 5). Some of the intrinsic factors that affected confidence were improvement from the last generation and the enjoyment of helping others. Most of the extrinsic factors involved the impact of individuals such as instructors, family, peers, and partners. These individuals could have a positive or a negative effect on student confidence. All but two of the interviewees cited that having a passionate science teacher in the past had affected their motivation to study science. This teacher usually had a profound effect on the student and the direction of his college career and life. When asked about the influence of high school science teachers on motivation to study science, Brian, a 19-year old aspiring doctor, stated:

> I did have this one teacher in high school. She was my chemistry [teacher]. She was a doctor. And she helped me out a lot. Whenever I spoke to her about the Marine Corps, her and I were really close, if I stayed after, she would… it always felt like she had high expectations for me. And… I don't know, it's corny… she helped me believe in myself in a lot of ways. The way she spoke to me, it's like a second mother type thing. I've never really had that. And, I love my mom and dad, but a lot of the raising, I feel like I just had to figure things out. And a lot of it's 'cause of me, 'cause I'm not really good at listening to her. So, high school teachers, they can impact. They definitely can.

This student stated that his teacher made him believe in himself and helped him build confidence. The interviewer followed up with, "She saw that you were talented?" And Brian responded: "Yeah. I feel like she always… she looked at me with a different set of eyes. And I like that. Yeah."

The influence of high school teachers might have been more important than college instructors because without their initial push, students might not have entered a STEM-related major. Eli said that his high school teachers built his confidence. He spoke at length about his high school experiences in his science classes as the biggest influence for enrolling in his biology class. His teachers encouraged him and gave him work outside of regular classroom assignments, such as taking care of the classroom aquarium and fish. These extra responsibilities helped to build his confidence even though he was already interested in the class.

> …I wanna say, the biggest influence out of all of my education was my 9th and 12th grade biology teacher definitely pushing me to – telling me that I was really good at this [biology] and don't forget that. And keep going with it. …I do wanna say I was pretty confident in myself. But definitely them telling me that I am good at this – I guess I wanna say that they probably -- the decision about what I wanna study is science. Because I was good at all the sciences that I took. But biology just stands out, I guess, out of all the rest of what I do.

External support came from a number of places, although the students sometimes felt they did not receive adequate support. In the case of Eli, his high school biology teachers gave him the support he needed. Teachers and instructors may not realize the importance of their words and actions towards a student, but in some cases it made a tremendous positive or negative difference. Marjorie, an aspiring veterinarian, made a statement about an instructor who improved her confidence. When asked whether she became more confident because she was accepted to a four-year college or because of her community college experience, she replied:

> I feel like at college, like I had a really good communications professor even though it had nothing to do with my major. Just like having those inspirational people that you listen to and you kind of realize – I'm doing the right thing; I'm going towards the right thing. There's a future in front of you and you've got to kind of reach for it.

For Marjorie simply having someone that was willing to listen was helpful, encouraging and confidence building.

Logan stated that his instructor was very good at making him more confident and made the class more interesting:

> She makes us more confident, like the whole class, because everyone likes to participate on certain subjects, though, like when you talk about reproduction or when we talk about how the fetus develops and everything else it seems like, I don't know, everyone wants to participate. It's fun and she makes us laugh and she talk to us about things that we are interested in, like I guess she knows how to connect with us. She's doing a good job because I usually mumble in the back of the class like answers, like she'll ask a question and I'll mumble it out loud, but in her class, I participate a lot.

When asked if there was something about the way she taught that made him more interested, he said:

> Yeah, like at four-year schools, they'll just go over the material or they'll go through the books or what ever and just talk, talk, talk. She'll actually stop, ask questions, and she'll try to involve the class more and talk about interesting things, so that helps.

The way an instructor taught made the class fun and engaging, which can help to increase student confidence. Engagement and active learning as opposed to traditional lecture style seemed to be important to gaining Logan's attention and interest.

James, a bachelor's degree holder studying to be a physician's assistant, stated that his instructor was very good at increasing his confidence, interest and motivation to study biology: "He explains a lot and makes you – he explains it to the point where even if you're not feeling confident, he'll do it until you do feel confident. I feel very confident in my abilities." Conversely, Maya, an aspiring physical therapist, recalled an instance when an instructor told her that science might not be right for her, which negatively affected her confidence.

> When I was in my chemistry class I wanted to meet with my professor. He said something, embarrassed me in front of the class and he goes to me on the side, he's like, 'Maybe it's not for you.' You know? And I was like, 'Oh.' And, I am a very sensitive person. So I think I take it to heart. And then it just stuck in my head. That's a semester I didn't go back to classes.

This instructor seemed to view students as having fixed intelligence, and projected his opinion so there was reinforcement of a fixed mindset for the student. Experiences such as these combined with a lack of strong guidance and career goal led her to take a hiatus from college. However, Maya returned to community college after a semester off, with the encouragement of her sister and enrolled in chemistry to repeat it. Although she struggled the first time she took chemistry and debated whether to return to college, she had an inspiring instructor the second time and a peer that served as her motivator and study partner. The instructor and peer promoted a growth mindset, and Maya went on to achieve better grades in chemistry. Even though she did well in chemistry she still debated whether science was right for her due to negative experiences in the course and with her first chemistry instructor. She demonstrated resilience in enrolling in her biology course where she capitalized on knowing the importance of having study partners to motivate her. She realized that she could do well with the right tools and appropriate amount of effort and time. This resilience was in part due to working with her peer who provided encouragement, but also because Maya felt that if this study partner could get a 96% then it possible for her achieve a good grade, as well.

When the researcher interviewed Maya she was profoundly affected by the other students and the shift in the classroom environment because students started to withdraw from her biology course. While some students tried to help her learn and encouraged her to study, other students were problematic. She had a study partner that she met every Saturday and after work some days who helped keep her motivated. However, she recalled:

> So I found this one girl and this other girl that she friends with … I don't know, I feel like she was always telling the other girls you know, to 'stay away from her.' You know, I'm just there. I just want to get you know – I just want to help. And you know… the motivation, I always tell the girl [female friend's name] 'Thanks, you're motivating me so I can do better in this course.'

But when she was asked why she thought the others said to stay away from her she said: "Well maybe it's sometimes people are like – especially in the science field, everyone is like, they try to psych you out and that stuff… Yeah, yeah, and very competitive." Kenny viewed competition from the opposite perspective, in that he had the competitive edge over others:

> I just find it funny when I hear other people say that they wanna be OTs [occupational therapist] and I look at myself and say, I should be happy that you wanna go OT, because you're gonna be my competition later on.

Competition was not always overt, but students were thinking about it due to the limited number of seats in select programs. These students knew they had to earn high grades in order to have a competitive application. Maya mentioned several times that some students were competitive and unwilling to help others. She also felt as though the classroom environment played a role in her and other students' confidence in the course. This showed there were important course characteristics that were not quantifiable. She did not waiver and stayed in the course, despite the laboratory assistant telling students they should drop out if they did not do well on an exam. She felt that people who were supposed to support her, such as the lab assistant, were not in the position to advise her on what she should do to succeed in the course. She also spoke about how students perceived the fact that many other students had dropped the class:

> Like the students themselves, I mean, we had a lot of students drop out… like I said my friend said, 'I'm going to drop out.' I said, 'you better not drop out. We've come so far.' And she's like, 'Yeah, but he's [the professor] freaking me out.' And the only thing that the professor said was you guys are not doing well. You need to step up your game. And

of course everyone was like, ‘Oh my gosh!’ It was – that was the day before the test. So people came to the class – people were dropping out that same day. ‘Sorry professor to do this.’ But I need to drop out. Yeah, I mean like the professor, definitely plays a role. I never really realized, and my sister who goes to [neighboring county’s community college] she’s always like on the rate my professor and she’s like you know. It didn’t really occur to me. I was like, ‘oh, okay.’ But he does play a role, you know, what professor you have. This professor, he’s good. But I just feel like he’s not like, there’s no push for the students.

She did not feel like he was motivating the class though he knew the material and conveyed it well. Although he told the students they needed to improve, he did not tell them how to change their study methods. The fact that so many other students had dropped the course, compounded by the instructor stating they were not doing well, had an effect on student confidence and motivation to persist.

Felicia discussed two different types of instructors that she had experienced – one that had a positive effect and one that had a negative effect on her confidence. She had always thought that her science and mathematics instructors seemed to care less than instructors in other disciplines, until she finally enrolled in biology. She was willing and forthcoming with questions, but past a science instructor did not seem receptive to questions. She felt held back by this unresponsive instructor, but she maintained a positive attitude and proceeded with taking additional science courses. She was pleasantly surprised to encounter a biology instructor who made her feel comfortable enough to ask questions. She reflected upon the sense of relief that the latest instructor would not break her confidence:

And so it was just like a sense of relief ‘cause it’s been so difficult trying to get a passing grade when the teacher doesn’t even put half the effort in trying to help you, especially if you question them and it’s like such an insult that it kind of makes you feel like you can’t do any better than what they want you to do.

She described her instructor as “not so intimidating like he doesn't expect you to know what he knows so he always says, ‘I expect you to not know what I know so that’s how I help you.’ So he’s different, definitely.” The support of the instructor and his responsiveness to questions fostered the growth mindset within the student. She spoke more about the effect of the instructors that are caring: “…they can make a difference if they actually put a little more effort into trying to care for people instead of just trying to care for what they’re trying to do.” By this she meant that the instructor was concentrating on doing his own research or something other than teaching.

When asked how the instructor affected her confidence, interest and motivation, Krista had many comments regarding his willingness to field questions and the tools that he gave the class. She particularly enjoyed that he narrowed the focus of topics that students needed to study for the exam. She said that he increased her confidence in her abilities:

So yeah, I like my professor. And I took him next semester too just in case. Because we already know each other and we already have a relationship… He keeps me motivated when I am in class because he tells me – I guess he points out the good instead of the bad, more. So I get support.

Some students developed a rapport with an instructor, particularly when the instructor taught both classes in a two-course sequence. The familiarity with an instructor made the students more comfortable and confident. Kenny felt the same way: “He’s very good at what he does. He’s very helpful and if I could take him next semester, it would be great but he doesn’t teach [anatomy and physiology II] next semester.”

These aspects of the instructor-student relationship should drive policy change for instructor training and hire. Teachers and instructors may not realize how personally a student may interpret their words, and how profoundly their words can impact the direction of a student’s life by either reinforcing or changing a student’s mindset. It is hard to teach caring, but some element of sensitivity towards students and their mindsets should be a consideration in teacher training and be introduced into orientation for new hires, if not a separate training course. Instructors should promote a malleable mindset and make students feel welcome to ask questions.

It was not always the instructor who served as an extrinsic factor affecting the mindset and confidence of the students. Family and significant others often played a role in building confidence and motivating. Marjorie relied on the support of her boyfriend to boost her confidence and keep her motivated to keep moving towards her goal of becoming a veterinarian:

> Yeah, like I said, like my boyfriend, he always tells me; he’s like, ‘You’re not going to have to live like this forever. Things are going to change.’ He tells me – I was doing my paper, like I was tell you when you called last night. He’s like, ‘you’re going to have to do the paper. Just remember you already got accepted into your school. All you’ve got to do now is complete – you’ve got to complete this semester, and next semester is less – almost a month, month-and-a-half away.’

She was excited about moving on to the next step in her education and towards her lifelong goal when he reminded her that her goal was within reach.

Family members can be a powerful motivating force. Krista she was not sure whether she would pursue nursing without having had her son. When asked who or what inspired her to study science, she responded:

> Probably I guess my son. Just to give him – I know like the science field is really broad, and I could basically expand anywhere I wanna go. So I really wanna do nursing, but I just feel like he’s my motivation for everything. But I don’t know if I would be here if I never had him. You know? So that’s it.

She was expelled from school in 11th grade. After she had her son she decided to get her GED and became a medical assistant. She continued to improve herself because she wanted a good life for her son and she felt like she could be someone”:

> I wanna be a nurse. I was thinking about doing the prenatal and neonatal courses. I know that’s very in depth ‘cause my professor tells me that all the time. But my influence is I just wanna change my life, my son’s life. I just wanna do good. I wanna be someone important. I don’t feel too important right now in what I’m doing.

Felicia stated that her parents were the ones who encouraged her and helped build her confidence to persevere.

> The only two people that never failed me are my parents, so they are the only two people that have told me: "Go for it, whatever you want to do go for it, it doesn't matter if it's science, it doesn't matter if it's art, so just do it." …They are just so different from [the rest of] my family, mom and dad's side put together, that I am kind of amazed at how I was lucky enough to be their daughter because everyone I know, like my cousins and stuff like that, I don't know how they are able to continue with their lives being treated like they don't belong or that they can't succeed in something. My parents are just so different. They're actually the ones that came here to the U.S. and actually have a home and actually put me and my brother and sister through private [Catholic] school... And so I just kind of always saw myself trying to be better. If I ever have a kid I definitely want to be better, give them more than what my parents have given to me. They definitely are my true supporters.

Felicia showcased her growth mindset throughout her interview. She kept working to get an education, even though she never graduated high school and struggled financially. She was overcoming obstacles. She had a supportive instructor and supportive parents that were reinforcing her confidence, which outweighed negative comments from an instructor.

Satisfaction. Satisfaction is when students "feel good about their accomplishments," and they are also more likely to be more motivated if the task and reward are defined and if they feel that they have some sense of control in the learning process (Keller, 1987, p. 6). Instructors can affect the satisfaction of students, which is related to confidence. The support of family also impacted students' satisfaction in their educational process. Extrinsic factors that affected students' satisfaction in a negative way were: 1) money being an advantage for others, and 2) the need to support their families. The need to work detracted from the time that they spent studying. Intrinsic factors in this category include student's perception of education as a positional advantage, appreciating opportunities, improvement from the last generation, helping others, and overcoming cultural obstacles.

Rebecca was a 36-year-old woman who grew up in Afghanistan and started college later in life. She was taking science classes to become a nurse. Even though she sometimes met with negativity and a lack of family support, she was determined to learn. Perhaps this came from her desire to overcome cultural obstacles and pursue her dreams. She said her husband supported her efforts to do well in her biology course as long as other aspects of their lives were not affected. Eleven of the twelve students interviewed expressed that improvement from the last generation was important to them, contributing to their satisfaction. So, the support of their family (or lack thereof) was related to this.

Other interviewees expressed the desire to make others happy. In some cases the student was working to make a better life for a child and improving from the last generation. Krista very clearly stated that she wanted to be a nurse to make a better life for her and her son:

> I just need to give him a foundation because I don't have a foundation. My parents never left me anything. My mother doesn't have anything. My father died when I was young. He didn't have anything anyway. [My son's] father is in and out of jail. He has no future. I have to give my son some type of stability because I never had anything, so this is why I do it. That's what motivates me.

She said making other people happy through her job also brought her satisfaction. She spoke about interactions with people at the doctor's office where she is a medical assistant:

> I feel like I could make somebody happy just for one day, and that's good. I feel accomplished if I made somebody else laugh 'cause they was cryin' a couple of minutes ago. You know? Make people feel better.

These experiences at work brought her satisfaction and this satisfaction reinforced her desire to go back to school in the medical field and to do well in biology because making people happy was a key motivator for her career goal.

Most of the interviewees believed that education was a positional advantage, or one's opportunities relative to opportunities that other people have available for themselves. Neither parent of Marjorie graduated high school. She appreciated academic opportunities and realized that education is a positional advantage that would be an improvement from the last generation:

> I mean I have friends that started [here at this community college] and myself and another friend, she dropped out earlier in the semester and it's like, oh, I can't hang out with you. I've got to go home and write a paper. And [she's] kind of like oh, that stinks. But in the long run, I'm like, yeah, it's going to stink for me, but in the long run, it's going to stink for you because you know – you're going to be working in retail probably and I'm going to have a career in what I truly want to do.

She also explained later that happiness is more important than money, yet money is really important in order to live a comfortable life. She viewed financial advantage as a means for independence and future security. Consequently, she was setting her sights higher than community college:

> I mean, that's kind of why I didn't want to stop at [being a] vet tech. I wanted to go to be a full vet because I want to be comfortable. I don't want to have to worry. I mean, my parents are in bankruptcy right now, so they're always constantly fighting over money and stuff like that. So I don't want to have that issue when I am older. I want to make sure everything's financially stable and I can – if I have kids, I can support them and don't have to worry about stuff. And, I know that they will be able to go to school and stuff like that.

Felicia spoke about where her extended family was from and how things in the U.S. were different from their country of origin:

> They are, they were all born and raised in El Salvador, you know cultural differences, education is a lot lower. Not until recently things have changed over there and I do have a couple of distant cousins who have made it to college. But even before that, being here it's just a lot more if you could say, what's the word, like it's so much more pressure being educated 'cause you can't even get a job here if you're not educated unless you want to be working at McDonald's. But over there – there's just, everything is different, you could find a job easily without an education so it's just very pressured [here].

She realized that a job that did not require education would "feel like it's a little too easy and not good enough." She demonstrated she felt capable and desired a better life than what she would probably have in El Salvador. She appreciated the opportunities that were available to her in the U.S. Overcoming these cultural obstacles brought her satisfaction and boosted her confidence. She realized that education is a positional advantage for her future that she likely would not have had in El Salvador. Positional advantage was created by her parents and helped stimulate the intrinsic desire for improvement from the last generation.

Eli spoke about his desire to get educated because he did not want to continue working long-term where he was employed. He discussed this after he was asked whether the fun aspects of his science course helped to keep him motivated in his studies:

> Yes. Because I have a job that I don't like right now, and I've had jobs in the past that I find absolutely terrible. So if I were to pursue a career in this field, I definitely – yeah. It's the old saying: 'If you like what you do then you never work a day in your life.' And that's what I want. I know a job is work but I don't wanna do something where I am miserable. I wanna do something where I can at least try and have some fun and enjoy what I do, honestly. It's just a retail job. I work at Target. It's just to pay for my gas money, essentially. But, also that job's also kind of like: I don't wanna be here for the rest of my life. I wanna get out of here.

He said that the prospect of having a good future was the most influential factor in motivating him to study science. He viewed his education as a positional advantage that could bring him satisfaction.

Maya also spoke about the push from her parents to do better than the last generation:

> I mean, I guess like everything falls back to you. But it's like if you don't have that push you know, my parents pushed me. Of course they pushed me. You know my parents are immigrants? They want to see you do better – me do better than them.

Her mother did not speak English, nor did she work, but she definitely wanted the best for her daughter. Maya felt a sense of responsibility to help contribute to the family household, even though it made being a college student more difficult:

> But, you know, the girl that I'm in with in anatomy and physiology, she has a family… but she's always here [at school], which I understand. But I'm working. And sometimes like when she wants to meet up [to study]… I'm like 'No I have to work or I have class.' You know? And it's harder because not that I am paying for like the house or whatever. But like, you know, it's hard. And especially like when your mom doesn't work and your dad is you know working all the time. You want to help your father out.

In this case, money was an advantage for others, like her classmate who could hire a babysitter, did not have to work outside the home, and could spend most of the day in the library studying. But Maya's sense of loyalty and obligation to contribute to her family was strong, though she wished that she had more time to herself and for her studies. The satisfaction that Maya could obtain from this course was compromised. Because of other her other responsibilities, the amount of time she spent on her coursework suffered.

Kenny stated that part of what was fun about science was feeling like he knew more than others:

> Knowing when you're with your friends and you can talk about the Krebs cycle or like, the electron transport chain and how they work, and they look at you like, 'Oh, how do you know that?' Well, that's how you make energy in your body and that's how it [our body] works out, but some people don't know that. Some people don't understand the whole process of how a muscle will move and you know, just knowledge. It's just knowing a little bit more than anybody else. I see life as a competition. If I can know a little bit more than you, then I'll be winning.

Knowing more than others due to the knowledge he learned in his biology class brought him satisfaction, kept him interested, and motivated him to study science. Kenny considered all options for his educational future though finances were a limiting factor. He said that if money were not an issue he probably would have taken a different path. However, he was not letting the financial constraints of an education deter him from capitalizing on what he chose. He decided to concentrate on getting his education now and would worry about paying the bill later. He was not going to allow financial restrictions to compromise his goals. Being satisfied along the pathway to the goal was important to keep him motivated:

> Well, when I was young, I wanted to join the Marines so they could pay for school and then I thought of it and said, 'No, I shouldn't do that.' But, yes, money was a problem before and still is sometimes, but I just- there's so many doors that could be opened with just hard work and continuing studying, but money sometimes is not really the problem 'cause I've seen so many people go to the school without paying a penny… But yeah, I mean, my cousin went. She went through law school and she did it. She has a debt, but she did it. It's – it could be an issue but I don't see it like an issue. I see it more like an obstacle that I'm just gonna go through it and I'll figure out later on what I will do. I always do that.

In addition to having to work to pay for their education, five of the twelve students stated that they also contributed to supporting their families, whether children or parents. For Kenny and many students, the need to work in addition to going to school strained their ability to have enough time to study and do well in their courses. Many students needed to do well in their science courses because high grades gave them better chances when apply for competitive programs. Students were often not satisfied with their grades and this was often a result of not enough time studying because of too many hours spent at work. When students' grades suffered they did not get accepted into the program of their choice and for some students their college education ended.

Relevance. Relevance involves relating instruction to present or future career goals (Keller, 1987). Although relevance is important to student interest in the subject matter and therefore their motivation to study science, and contributed to attention and satisfaction, students cited the least amount of factors that affected this construct compared to the others The most commonly cited factor was that students were motivated to study biology because it was directly related to their career goals. Five of the twelve students stated they were enrolled in a particular course because they were following in the footsteps of a family member's career that was STEM-related. One student's mother worked as a chemist in a laboratory, but most other students had a relative working in healthcare. This direct family link to a STEM career helped cultivate science course relevance to the student.

Studying diseases that have affected and continue to affect so many people throughout the world can provide relevance to a topic. Sandy stated that when she was part of a research project involving 4-phenylphenol that her interests were peaked because of the possible links to Parkinson's Disease and Alzheimer's disease. She said that performing research was serious, but also fun.

Brian realized that topics he was learning were actually relevant to what he wanted to be:

> I took Chemistry 101. I couldn't stand it. I was like 'What's the point of this?' And then I had a lab partner. He was an older man. He had a family and everything. He was a nurse trying to move up in his career. So he came back to get some prerequisites to go on in his schooling. And he taught me a few things. I remember complaining like, 'Oh this class is dumb.' And he was like, 'Well, what do you want to do?' And I'm like, 'Well, I'm thinking sports medicine, but somewhere medical, and I need this class.' And then he told me, 'Well, if you're trying to help an athlete out, and you don't understand what he's eating will break down in his body all from the Krebs cycle,' and all this other stuff I was learning within that bio class, Bio I. And I was like, 'I guess you are right.' You do need the Krebs cycle. And what going on inside of the organelles that goes on inside the cells, what's going on inside of this creates me. Yeah, that's when I started to really like science and started to be interested in it.

Students need to make connections between the material that they are required to learn and why it is relevant to their lives or careers in order to increase their interest and motivation.

Rebecca was always interested in becoming a nurse because her mother was a nurse in Afghanistan. Now that she was older with her own children she returned to school to follow her dream. She was particularly interested in her science courses and doing well in them because they were relevant to getting accepted into a nursing program, which tends to be competitive. When asked if she thought science being fun helped to keep her motivated she said: "How can I answer this question: "Sometimes it's fun, sometimes it's challenging, sometimes it's something that I need for my career, so it's…" When asked if a challenge can be fun she replied, "Yeah, sometimes. It's like my instructor used to say, you have that 'a-ha' moment when you understand it and that is fun. Once you understand it you're like, okay, this is really interesting." Some students did not enjoy learning for the sake of learning, but when they did, they were often more attentive, satisfied, and motivated. She viewed learning as being fun and that kept her interested and motivated when she finally grasped a topic.

In summary, the most commonly discussed qualitative data are summarized for each interviewee along with each individual's change score in Table 21.

Table 21

Recurrent Codes in the Qualitative Data and Individual Change Scores

Student	Positive influences related to interest	Negative influences related to interest	Change score
Felicia	Instructor's attitude affects me Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Have a clear career goal Becoming an adult/realize responsibility Partner encourages Overcoming personal obstacles	Instructor's attitude affects me Math is a factor Money is an advantage for others Advisor/someone discouraged me regarding science	-13
Krista	Instructor's attitude affects me Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Education as a positional advantage Enjoys academic challenge Happiness is more important than money Have a clear career goal Becoming an adult/realize responsibility Partner encourages Overcoming personal obstacles Small class size/personal attention from instructor	Math is a factor Money is an advantage for others Work is a distraction from academics	+7
Rebecca	Instructor's attitude affects me Higher goals than community college Instructor tries to help us understand/is interesting Support of family Enjoys academic challenge Happiness is more important than money Have a clear career goal Partner encourages Small class size/personal attention from instructor	Math is a factor Counselor/teachers not making students STEM aware	+9
James	Instructor's attitude affects me Math is a factor Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Passionate science teacher in past Education as a positional advantage Happiness is more important than money Have a clear career goal Small class size/personal attention from instructor	Advisor/someone discouraged me regarding science Counselor/teachers not making students STEM aware	+17
Sandy	Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Happiness is more important than money Have a clear career goal Overcoming personal obstacles	Instructor's attitude affects me Math is a factor Advisor/someone discouraged me regarding science Counselor/teachers not making students STEM aware Work is a distraction from academics	+6
Kenny	Instructor's attitude affects me	Money is an advantage for others	-3

	Math is a factor Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Happiness is more important than money Have a clear career goal Becoming an adult/realize responsibility Small class size/personal attention from instructor	Work is a distraction from academics	
Eli	Instructor's attitude affects me Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Happiness is more important than money Overcoming personal obstacles Small class size/personal attention from instructor	Math is a factor Money is an advantage for others Advisor/someone discouraged me regarding science Counselor/teachers not making students STEM aware	+10
Logan	Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Have a clear career goal Becoming an adult/realize responsibility Small class size/personal attention from instructor	Instructor's attitude affects me Math is a factor Money is an advantage for others Counselor/teachers not making students STEM aware Work is a distraction from academics	-65
Laura	Instructor's attitude affects me Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Happiness is more important than money Becoming an adult/realize responsibility	Instructor's attitude affects me Math is a factor Money is an advantage for others Advisor/someone discouraged me regarding science	-21
Marjorie	Math is a factor Higher goals than community college Improvement from last generation is important Support of family Passionate science teacher in past Education as a positional advantage Enjoys academic challenge Happiness is more important than money Have a clear career goal Becoming an adult/realize responsibility Partner encourages Overcoming personal obstacles	Instructor's attitude affects me Money is an advantage for others Advisor/someone discouraged me regarding science Work is a distraction from academics	-37
Maya	Instructor's attitude affects me Math is a factor Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Education as a positional advantage	Instructor's attitude affects me Money is an advantage for others Advisor/someone discouraged me regarding science Counselor/teachers not making students STEM aware Work is a distraction from academics	No post

	Enjoys academic challenge Happiness is more important than money Have a clear career goal Becoming an adult/realize responsibility Partner encourages Overcoming personal obstacles Small class size/personal attention from instructor		
Brian	Instructor's attitude affects me Higher goals than community college Improvement from last generation is important Instructor tries to help us understand/is interesting Support of family Passionate science teacher in past Enjoys academic challenge Happiness is more important than money Have a clear career goal Becoming an adult/realize responsibility Partner encourages Overcoming personal obstacles Small class size/personal attention from instructor	Math is a factor Money is an advantage for others	-6 -17

*Science can be fun and supportive instructor were not listed in the table since all students stated these as positive influences.

4.7 Connections Between Qualitative and Quantitative Data

The qualitative data were important to provide deeper insights regarding the quantitative results. Details about how students felt about their science coursework at the community college reinforced the complexity of factors that affect interest and motivation to study science. Factors such as personal responsibilities, individual characteristics of instructors, and various course elements made the educational experience uniquely different for each student. All of these components played a role in the ability of the student to find relevance, build confidence, maintain attention, and derive satisfaction from their learning process. Instructor, student, and course characteristics had effects on interest and motivation. This will be discussed by each respective category, followed by the combined predictors elucidated by the binary logistic regression, and associations with qualitative data.

Instructor characteristics and effects on interest and motivation. One of the most important outcomes of both the quantitative and qualitative results of this study is the need for training college instructors to be equipped with tools to best assist their students. The quantitative results showed that students' interest increased from beginning to end of the semester when taught by an instructor with a degree or certification in education. Instructors that have gone through the process of attaining a degree or certification were likely to be better equipped as educators compared to those that had no formal training in education. The next most significant attribute for the instructor category was full-time compared to part-time status, with part-time instructors having only a slight decrease in interest while those taught by full-time instructors had a significantly lower level of interest by the end of the course. Most full-time instructors (6 of the 8) in this study did not have pedagogical training of any kind, but only 33% of the part-time instructors lacked pedagogical training. Some part-time instructors were medical practitioners, some were laboratory science researchers, some were educators with a full-time job at another college, and some were high school educators. Students had a lesser decrease in interest in their biology course when taught by instructors that had taken education courses, instructors that taught high school, and did not have a doctoral degree. Ironically, concerns have been expressed regarding the quality of education that part-time instructors provide (Eagan & Jaeger, 2009; Jacoby, 2006), but these results suggested that students' interest in biology was better served by part-time instructors.

The students interviewed stated they had a passionate teacher in the past who helped develop their interest. Most interviewees also stated that their instructors' attitudes affected them. Being supportive, in part by giving personal attention and making science more interesting, was an important attribute for increasing interest and motivation to study science. College instructors and their students would benefit greatly from pedagogical training. Training should address techniques to keep students interested by making coursework more relevant to their career goals and everyday lives. Promoting a growth mindset and working to eliminate the fixed mindset will help build confidence. When students were confident and attentive they tended to do well and were satisfied with their academic pursuits. Perhaps instructors that had pedagogical (and andragogical training) in the past already possessed some knowledge regarding how to motivate students. However, practicing educators that were formally trained might not have been current with the latest in science education research and methods to engage and motivate students. Professional development throughout an educator's career is necessary to best serve students. Students were often balancing jobs with family life and trying to get an education as way to become more socially mobile and improve from the last generation.

Some students were non-traditional and were returning to school later in life and their study skills may have been lacking. Many students stated they enjoyed the personal attention in a small classroom setting. Some instructors were not equipped with the tools to relate well with students in a way that garnered respect and showed caring. Fostering an environment where students felt comfortable asking questions was important. It can be difficult to strike a balance between the demands of the curriculum and creating a welcoming environment for questions and discussion. This, in part, is why continuous professional development throughout an educator's career is necessary. Many community college instructors knew the demographic and took the time to ask students about their personal needs and express some sensitivity and understanding. With new developments in educational research, there will always be new ways to improve skills and abilities to facilitate learning. The results of this study suggest a need for additional knowledge and skills for community college instructors to promote student interest.

Significant student characteristics and effects on interest and motivation. Age was a factor in showing significant differences in student interest. Students 25 and older showed an increase in interest while those that were 18 to 24 years old showed a decrease in interest. Older students may be more serious about their studies, may be paying out of pocket for school and balancing the demands of having familial responsibilities. These attributes might make these students more serious about their courses.

Degree holding status was the other student characteristic associated with an increase in interest over the course of the semester. Two of the interviewees were degree holders and in both cases they were attending community college to take prerequisites for graduate programs. These students may have been more focused on doing well in the course since such programs are highly competitive, which helped to increase their interest and motivation.

Ironically, students that had a STEM-related career goal actually had a significantly larger decrease in interest compared to those that did not have a STEM-related goal. Frustrations were high and clouded their ability to stay interested. Most of the students in the service courses knew that if they didn't get an A in their courses they would not be viable candidates for their intended programs. Many students found comfort in bonding with other students in the course, while some others would see forming a study group as a hindrance because they were in competition and did not want others getting a better grade.

Significant course characteristics and effects on interest and motivation. Half of the interviewees were taking service courses and this was the course type that showed less of a decrease in interest when compared to those taking majors courses. None of the interviewees spoke about library research projects because they were not typical in these courses because of the demands of the curriculum and time constraints. Interviewees mainly spoke about their instructors and their study partners when asked about the aspects of their biology courses that increased their interest in science and motivation to study. One of the students spoke about the attrition rate of the course and that students were worried that maybe they should drop out, as well. Fun activities, such a dissection, were also mentioned as motivating course characteristics.

Combined effects influence on interest and motivation. The binary logistic regression showed that students holding degrees, older students, those that did not have STEM-related career goals, were taught by a part-time instructor, had an instructor that had high school teaching experience, and took their classes in the evening had the highest likelihood of increasing interest during the course. All of the interviewees actually had STEM-related career goals and only 5 of the 12 showed an increase in interest. When speaking to students who had part-time instructors who were medical practitioners or high school teachers, they expressed greater interest and felt more support. Age was not always evident when speaking with interviewees. However, some of these students as very young adults had been through some very trying times and had to grow up quickly. This seemed to be a common thread with community college students – they always had a story to tell and many times it involved hardship. This reinforces the need for compassionate instructors who also maintain high standards.

4.8 Summary of Results

Data analysis with ANCOVA showed that there were several characteristics of students, instructors and courses that were significant in students' change in interest over the span of the semester. Interest in the biology course increased for students 25 and older and previous degree holders. Comparison of CIS means from pre- to post- by grouping students who agreed or disagreed with Background Factors and Personal Experiences Questionnaire yielded results that were consistent with a number of qualitative findings. Results are best summarized in bullets.

Student interest in their biology course significantly *decreased* when students:

- Believed high school science courses had a positive effect on career goal.
- Said they were interested in their high school science classes.
- Said high school science classes were fun.
- Agreed that they were made aware of STEM careers in high school.
- Agreed they enrolled because interested in this biology class and what they will learn.
- Agreed they enrolled because it is a pre-requisite for a program they are applying to.
- Agreed they enrolled because they want to know more about how their body works.
- Said main motivation for career choice was to make lots of money.
- Said main motivation for career choice was interest in science.
- Said main motivation for career choice was that they enjoy helping people.
- Said main motivation for career choice was due to familial or parental expectations.

- Said parents said it would be a good career choice.
- Said that supporting their children or future children affected their career choice.
- Made their career choice to support children or the ones they will have.
- Said their ethnic background/culture valuing education affected their career choice.
- Said main motivation for career choice because it always what they wanted to do.
- Said main motivation for career choice was they thought it would be easy to get a job.
- Said main motivation for career choice was job security.
- Disagreed that they were more confident that could do well in another biology course.
- Disagreed that they were more interested in taking another biology course.
- Disagreed that they were motivated to stay in or change to a STEM career.

Student interest in their biology course significantly *increased* when students:

- Disagreed that they were interested in this biology class and what they will learn.
- Disagreed with main motivation for career choice: to make lots of money.
- Agreed that they were more confident that could do well in another biology course.
- Agreed that they were more interested in taking another biology course.
- Agreed that they were motivated to stay in or change to a STEM career.

The community college students were influenced by instructor characteristics and relationships with their instructors. Classes whose instructors possessed an education degree or certification showed a mean increase in interest, while classes of instructors that did not showed a significant decrease in interest. Part-time instructors' students had a slight decrease in interest, whereas the full-time instructors' students had a significantly larger mean decrease in interest over the course of the semester. Other characteristics showed significant differences between both subsets, but in each case interest decreased significantly less when the instructor had taught high school, had taken education courses, and did not possess a doctoral degree. This shows that instructors with pedagogical training were more likely to retain or increase community college student interest. Most community college instructors do not have a degree in education, rather, they possess at minimum as master's degree in their field of specialty (Outcalt, 2002). Higher education faculty may possess little knowledge about student learning theories and teaching methodologies related to pedagogy and andragogy.

Elements of the course itself were significant, as well. When the attrition rate was 10% or higher for the course the remaining students had a significantly bigger drop in interest compared to those students that were in a class with lower attrition rates. This may have had something to do with how the course was taught. The changing classroom environment may have affected students' confidence and attention. When students had a library research project assigned, their interest increased, while student enrolled in a biology class without a library assignment showed a decrease in interest. The type course was also significant. Biology majors showed the largest decrease in interest. The students that showed the smallest decrease in interest were those in elective courses. Service courses, which were predominantly prerequisite courses taken by students wanting to apply to an allied health program such as nursing, occupational therapy assistant, or physical therapy assistant had slightly more of a decrease in interest than electives. It may be that those on a more focused path of study who were applying for a competitive program had more interest in their courses compared to students who were less certain about career goals but were majoring in biology.

The binary logistic regression model showed six significant variables that increased student interest. Older students, previous degree holders, students that took courses at night rather than during the daytime, students who were taught by instructors that taught high school, instructors who taught part-time, and students who actually had a major other than one related to a STEM career had higher interest in their biology courses than their counterparts. This model correctly classified 64.0% of the overall cases, which was an improvement from the null model of 53.9%. When students were taught by a part-time instructor they were 2.05 more likely to have an increase in interest. This odds ratio was closely followed by students having an instructor with high school teaching experience, their interest was likely to double in this scenario. These results corroborate some of the results of the ANCOVAs. Four of the six significant variables of the binary logistic regression model are consistent with the significant differences with small and small/medium effect sizes from the ANCOVAs for all student, instructor, and course characteristics. While ANCOVAs investigated the *individual* effect of the different options for one independent variable on the dependent variable, binary logistic regression elucidated the effects of *several* independent variables ability to predict the dependent variable at the same time. These findings may serve to develop interventions to improve student interest in science at the community college.

The categories derived during axial coding were: altruism, childhood struggles, academic support structures, external support leads to mobility, personal experiences motivate, and pride and self-esteem. From the axial code categories the themes that emerged demonstrated that students' interest and motivation in their biology coursework were influenced by a combination of extrinsic and intrinsic factors. All qualitative results emphasized the instructor's attitude towards the class was likely the most important extrinsic factor that impacted their interest and motivation. Most students mentioned other individuals in their lives that were important, such as family, partners and classmates. All students appreciated the support of instructors, and the instructor making the course fun affected their engagement and motivation to study science. One of the most important intrinsic factors was the participants' feelings about mathematics being factor in their interest in their science courses and their abilities to achieve in science. When students were less confident, as they sometimes were due to their feelings about mathematics, they sought external validation from their instructor. A new model was then derived from the theoretical framework, the constructs of the instrument, and the factors that emerged from the qualitative data affected each (Figure 5).

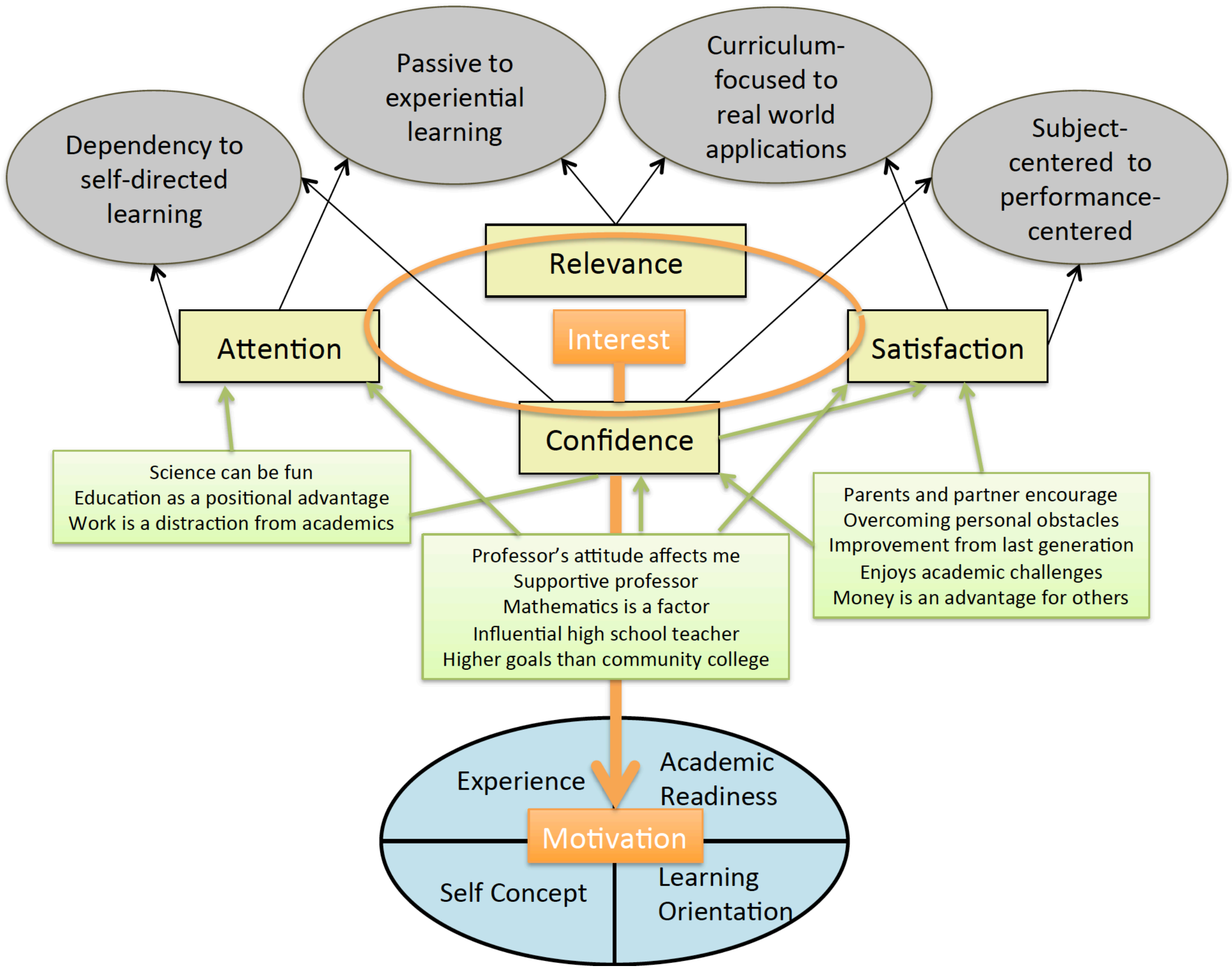


Figure 5. Theoretical framework with qualitative contributions.

Each of the factors was classified into one or more of the four constructs of interest of the instrument used to obtain the quantitative results. The factors that were gathered during the qualitative study contributed to the four constructs of the instrument. That same instrument was used for gathering the quantitative data through ANCOVA, paired samples *t*-test, comparison of means, and binary linear regression allowed for triangulation of the data in this study elucidating important intrinsic and extrinsic student factors that affect students, and the student, instructor, and course characteristics most in need of intervention to increase student interest and motivation to study science.

Chapter 5

Conclusions and Implications

5.1 Introduction

The findings of this study showed that there were significant student, instructor, and course characteristics that affected change in student interest and motivation to study science. Knowles (1980) stated that adults must be interested in a subject for their attention to be retained and therefore learn. Adults learn differently than students enrolled in the K-12 system due to the elective nature of their academic pursuits. The four assumptions of Adult Learning Theory are: 1) self concept of the learner, 2) role of learners' experience, 3) readiness to learn, and 4) orientation to learning (Knowles, 1980). These assumptions were evident in some of the student, instructor, and course characteristics related to change in student interest. These assumptions were also related to life experiences of the students and effects were observed in the qualitative data.

Investigation of a few variables showed a significant increase in interest while others showed a decrease. In many cases a decrease was seen in both counterparts but a significantly smaller decrease in interest of one in comparison to the other. This showed that on the whole, a variety of interventions is necessary to improve community college students' experiences so their interest in biology coursework increases.

Instructors who possessed a certification or education degree had students that showed only a slight increase in interest, and those that had taken some education courses or had taught high school had students that showed less of a decrease than their counterparts. Therefore, *pedagogical* techniques may not be the answer; community college students would be better served if instructors possessed and utilized *andragogical* techniques. Pedagogy focuses on teaching a child, whereas andragogy is the science of teaching adults. The motivation of learning for a child is different than that of an adult; children are required to go to school, adults usually choose to be educated because they have particular goals. The difference in techniques is best explained by the assumptions of Adult Learning Theory, which require change in learning activities for adults. An adult should view education as self-directed with shared responsibility with the educator. The educator needs to facilitate that change in mindset for adult community college students. Adult students' past experiences should enable more meaningful learning facilitated by the educator, gaining knowledge from connections with experience rather than passive lecture. Learning tends to be more meaningful for adults when the topic can be applied to authentic situations. Educators of adults should implement more activities that require the application of knowledge because adults encounter real problems in their everyday lives that require solutions. Relative to this is the adult's orientation to learning, in that they want to utilize their knowledge and skills to achieve their goals; therefore, movement toward performance-based rather than content-centered learning should take place.

Crucial support was often provided by community college instructors. Administrators, instructors, counselors and advisors need to cater to the needs of their students by having professional development training sessions regarding implementation of andragogical techniques consistent with Adult Learning Theory. As the qualitative data revealed, past experiences stay ever present in students' minds as they arrive in community college. Just as students must be willing to accept that those experiences cannot be changed and have shaped who they are, instructors must also be cognizant that community college students have experienced many types of struggles. Instructors should be sensitive to these struggles, promote a growth mindset, and be utilize andragogical techniques. Since using students' past experiences as a learning tool is one facet of adult learning, the benefit in understanding the student population is two-fold.

The purpose of this chapter is to identify the conclusions and implications of the results as they apply to policymakers, administrators, community college instructors and educators at the primary and secondary level, since developing early interest in science is beneficial. This study is of particular interest to administrators and policy makers in order to formulate interventions that create the ideal learning environment for community college students. These individuals must consider what can be done to strengthen positive relationships between students and instructors.

There is value in sharing data about improving community college students' success and persistence in science. Understanding and respecting the diverse characteristics and needs of community college students will help engage them in the learning process, and will provide a context for developing interventions that improve participation and retention in science and STEM-related careers. Suggestions for the necessary interventions to foster an environment that promotes increased interest and motivation for community college students to study science will be discussed in respective categories of student, instructor and course characteristics.

5.2 Addressing Student Characteristics

Policy makers need to ensure that proper academic and social support systems are in place for community college students enrolled in science programs. One of the students interviewed previously attended a four-year school and stated that it was much easier to meet other students to form study groups when you live on campus. It can be a struggle for community college students to make connections and form bonds with other students as commuters. Transportation can also be a challenge for these students, and missing class can impact their studies and their grades. As shown throughout the qualitative data, external validation and support structures were necessary for community college students' motivation to study science. Community colleges need to facilitate ways for students to meet, network, and bond. Creating the infrastructure to provide meeting spaces for these commuters to study and socialize with peers is essential in developing personal support structures.

Younger students who may actually have less work and family responsibilities showed a significant decrease in interest in biology in comparison to students that were 25 or older. Younger students may need more attention in order to retain their interest. These students need to be targeted to join campus clubs and activities to become more socialized and further develop interests, form study groups, and participate in undergraduate research. The ability to create and sustain student interest in coursework and other aspects of college life is important for persistence and success. High school bridge programs should be implemented to help prepare community college science students for the rigors of these courses.

Students who have little to no previous college experience may also require some intervention. Degree holders are likely returning because they have changed their career goals, are taking prerequisites and are focused on applying to programs. Students that do not hold degrees may not be as focused and might still be investigating career paths. They can learn from the experiences of returning students. Shared experiences can help them critically consider whether their career goals are going to make them marketable. Administrators and counselors need to ensure these students are well informed about current and projected job markets. Strengthening articulation agreements with four-year institutions will help facilitate advanced educational opportunities for community college students. Programs to shadow professionals should be created and internships should be facilitated to create awareness of career possibilities. Community colleges should recruit high school students with the desire to enroll in STEM-related programs so the students can prepare by taking appropriate pre-college coursework. Well-defined career aspirations will facilitate course interest and persistence. Community college students need to understand the steps required to reach these goals, which will strengthen their recognition of the relevance of their coursework.

Money was a concern for many students and it should be a concern for policy makers. Financing an education in order to improve one's life can be difficult. Social mobility almost always requires higher education. Education provides a positional advantage but it can be expensive for many students even though community colleges are typically the most affordable option to further one's education. Colleges should insure that financial counseling resources are readily available and advertised to students. Not only is complete awareness of financial aid options for both full-time and part-time students important, but guidance with regard to employment to course load ratio would be beneficial. Sometimes students do not realize the downside of overscheduling themselves in terms of time and financial resources.

Community college students themselves would benefit from knowing the findings of this study so they are aware of common struggles. Learning from shared experiences is important, therefore, students can learn from the interviewees' accounts as well as the implications resulting from the data. It is important for community college students to understand their education is a shared responsibility with the instructor. Orientation should be required for all students and it should include meeting and conversing with instructors so that students realize instructors are accessible, approachable, and are working in the students' best interests. A component of orientation should also teach students how to approach instructors, remind them that it is important to ask questions, and encourage them to utilize office hours and the resources that are available to promote success. During this time the students should also be made aware of the resources and support systems that are available and have been built specifically for them. Navigating the college experience without a foundational sense of community can be daunting. A sense of community may begin with a strong orientation program when students can start to develop relationships with classmates and instructors. Support should continue with development of student learning communities.

5.3 Instructor Characteristics

It is important for science instructors to be cognizant of their skills and deficiencies and always strive to improve for the benefit of community college students. Achievement of a terminal degree does not imply that teaching methods cannot be improved. The results of this study showed that even some of the instructors who had pedagogical training could not effectively increase interest of their students. Andragogical training would be more beneficial for this adult population of students with unique circumstances and perhaps yield increased interest in science coursework. As described by Adult Learning Theory, students move towards more self-directed, experiential, performance-centered learning with real world applications, and move further from an instructor dependent classroom model. Instructors need to realize that they and their students will greatly benefit from taking education courses and attending professional development to learn how to promote a more independent style of learning, yet still be available as a supportive individual. As these data suggest, being an expert in your field does not necessarily mean that one can teach the material well enough to retain or increase student interest. Instructors that do not possess educational training of any kind should be enrolled in professional development and administrators should encourage applicants to participate in andragogical training before they are hired. Administrators should provide timely examples of successful implementation of adult learning techniques to all faculty.

Instructors need to explore innovative ways to create and increase student interest in order for them to stay motivated, persist, and succeed in STEM-related programs. Infusion of relevance of the material to the students' future career is essential to maintain or increase interest. Instructors need to take the time to make required material relevant despite the demands of an often overloaded curriculum. Instructors must attempt to vary their methods to recognize that students can learn just as well if not better from active learning and flipped classroom activities. Students are best served by the instructors keeping the required curriculum as interesting as possible, in part by making it relevant to the students' career goals. If students do not have STEM-related career goals, they will benefit by improving their scientific literacy and becoming more informed citizens. Instructors should share successful methods and instructional tips with their colleagues through campus workshops and seminars.

Ultimately, the instructor needs to buy into the idea that she can improve her methods by attending andragogical training. Instructors need to ask themselves how they can be sure that their students are learning what they are teaching. Instructors should also encourage their colleagues to attend professional development and share successful ideas with one another. Community college instructors (and therefore, their students) can also benefit from developing learning communities to discuss the collective needs of the students and what they can do to change and create better support systems. These instructors should have a research plan in place before they implement changes to measure effects on student needs, outcomes, interest and motivation. Community college instructors should consider developing research studies in order to inform the science education community about their experiences and the needs of their students. Their findings need to be shared with their campus community as well as educational research audiences on a national scale.

When resistance from instructors is met by them stating that the do not have time for development of new techniques, administrators should offer incentives like a teaching and learning center to provide services and designers that can help to build specific instructional tools and strategies. Such tools and strategies include case studies to incorporate depth and application to the lesson and curriculum mapping to ensure that what is required is actually emphasized. This may alleviate time restrictions that prevent attempts at incorporation of new learning activities that make the material more interesting to students. When resistance from administrators is met due to financial constraints, faculty should know that there is significant literature regarding activities that cater to the interest of the adult learner.

Community college administrators need to be aware of these preferred instructor characteristics, which should drive changes in hiring practices and professional development. Administrators should hire those already trained or encourage veteran instructors to become properly equipped to help students succeed and persist in STEM-related programs. It is ideal to hire faculty who have training in andragogy because requiring andragogical training after an instructor is hired can be prohibited due to contractual limitations. When hiring those with no pedagogical or andragogical training, administrators should implement some strategies as part of new faculty orientation. Community college administrators should incentivize education research since research is often not a contractual requirement of community college instructors. Community college instructors have a data rich resource at their fingertips and the science education community needs to become more aware of the needs and unique characteristics of community college students. Administrators should also require or incentivize part-time instructors to hold office hours. The majority of community college instructors nationwide are part-time instructors and their students should be afforded the same benefits as the students enrolled in a full-time instructor's course. As indicated by the data, students appreciated one-on-one time with and personal attention from their instructors. Without additional access to the instructor, in-class time is the only opportunity for students of part-time instructors to gather feedback or have the additional assistance they may need.

Many community college instructors may be aware of the challenges their students face, but they might not be aware of how to handle those challenges properly. For example, the concepts of fixed and growth mindsets may not be familiar to many community college educators. Even if instructors had pedagogical training, they may not be aware of the current best practices in adult learning. Instructors need to understand concepts and current topics in educational psychology as they relate to community college students in order to avoid unintended negative consequences during exchanges with students. Even four-year institution instructors that will be inheriting some community college students through transfer should be made aware of techniques to better support their students. College administrators should implement training for existing staff and plan to provide meaningful professional development because there is always something new that can be learned based on the latest developments in education research.

Administrators at the K-12 level should insist upon mandatory updates for guidance counselors regarding job market trends in order to improve student awareness of STEM-related careers. Students need to be better informed about career options that are available to them during high school so they can start thinking about these possibilities and investigate careers in the early stages of community college attendance. Students are less likely to waste time and money if they are better informed of career options in high school. These administrators should also implement training for their faculty to infuse interesting science topics into the curriculum so that students can start to develop interest.

5.4 Course Type and Category

As was seen in data for course type, it is particularly important to note the career path of the student and his associated needs. Students in certain degree programs and courses may need special interventions in order to develop or increase interest. Biology majors need to stay interested in their coursework in order to persist in the major, and the instructor's pedagogical skill was a crucial variable in this process. Students in elective courses should experience the same types of reforms to improve interest, since major and career choices were often influenced by impressions formed in introductory coursework. Students should be made aware of cross-disciplinary options for career opportunities. For example, an art student might enjoy her biology course and want to incorporate both her love of art and new interest in science into a career as medical illustrator. But the student might only discover this if the instructor has taken the time to realize that she has an art student in class and notes this student has an affinity for biology. Students in the service and programmatic courses showed less of a decrease in interest as a group, in comparison to biology majors, mostly because they were already focused on a particular career, yet their interest was not growing. There is always an aspect of the course that can be improved by the instructor to generate and strengthen student interest.

Even editing course objectives to include something as simple as a library research project can inspire the students and promote interest in related topics outside of the required curriculum. When students had the opportunity to investigate a topic of interest in conjunction with a research assignment, they discovered new ideas. Community college administrators should encourage the faculty to assign more personalized or library assignments that might lead to self-discovery. Course objectives need to be explicit so that students can select courses based on what matches their interests and know what is expected of them. Instructors need to adhere to those course objectives. Students may have lost interest in the coursework and perhaps their career goals because either the expectations were not made clear or the coursework did not match what they envisioned was required to attain their career goal.

Instructors should remind students in courses with high attrition rates that their abilities and grades are not related to the others who withdrew. Students certainly do drop out because of failing grades, which could in part be a reflection of instructor characteristics and lack of support. But some others might be leaving the course due to life circumstances, such as finances, family, or health, things that have nothing to do with their achievement. Remaining students need to know that they should not feel discouraged by attrition rates because they all have the potential to succeed when they invest enough time and effort.

Since evening class students were more likely to be interested in their coursework than daytime students, evening and daytime instructors should convene to discuss their different methodologies or attitudes toward the class to see what might be beneficial for the daytime instructors to incorporate into their course. Perhaps evening instructors teach their courses with a unique perspective that engaged the students more actively. Colleagues sharing ideas about their classroom management styles may be beneficial for the students. Evening course students might also be more likely to be older students or overlap with previous degree holders category, and evening instructors might be pedagogically trained or teaching at the high school level during the day. Confounding variables should be explored in future research.

5.5 Future Research

Future interventions should be implemented to address issues with STEM course interest of community college students. Studies should be done comparing students' change in interest and motivation when taught by instructors who utilized andragogical techniques as opposed to a control group. Attrition rates of trained instructors could be compared to those instructors who do not use adult learning strategies. Longitudinal studies are important in determining whether students persisted in STEM post-secondary study in part due to andragogical techniques. Investigation of how the instructors view professional development in andragogy would be interesting, as these instructors might not be aware that they were not properly targeting the needs of community college students.

Comparison studies could be done with students who utilized financial counseling resources as opposed to those who did not. Investigation into how students altered their work to course load ratio once they became better educated about time constraints and required effort to achieve desirable grades would reveal the impacts of such treatments. Studies of the development of student learning communities and the impact on student interest, motivation and persistence would be relevant since students rely on support from others. Studying the methods and interactions of the instructors and facilitators of such learning communities would also be important.

Entering students can be surveyed regarding the effectiveness of high school bridge programs and increased awareness of STEM-related careers provided by high school guidance counselors. Elucidating what the specific qualities of their passionate high school teachers that had an important impact on development of their interest in science is crucial. Additionally, which specific qualities of those college instructors that also had education degrees, certifications, or had taught high school were most important in increasing student interest in science needs to be investigated. A qualitative study of comparing evening to daytime students might reveal what makes this variable one that helps to predict increased student interest in their biology coursework. Perhaps even more telling would be a qualitative study to elucidate possible differences between evening to daytime instructors and the specific ways they interact with their students in relation to Adult Learning Theory.

5.6 Summary

This study speaks to the need to find ways to increase student interest, which has an effect on motivation, achievement, and success. These data suggested that interventions with community college instructors, course objectives, and creation of meeting places for students to bond and study together may be beneficial for increasing student interest and motivation. Informing administrators, instructors and policy makers that improvements in community college teaching techniques and support structures can benefit student interest and motivation is essential in ultimately leading to more students persisting in the pipeline, joining the STEM workforce, or transferring to four-year colleges. Understanding community college student characteristics can lead to customization of methods, objectives, and supportive policies to meet student needs.

Serving the needs of community college students in STEM requires an understanding by all educational professionals, not only community college instructors, but also teachers who are preparing K-12 students, guidance counselors, and instructors at four-year institutions who are inheriting them as transfers. Only a handful of peer-reviewed journals dedicated specifically to community college research exist. Yet, nearly half of all post-secondary students have attended community college. Community colleges present a rich, diverse, and relatively untapped talent resource that may be of interest as a future direction for research in STEM persistence.

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Appendix A

Course Interest Survey

LAST 4 DIGITS of SCCC Student # _________ Course Code___________

Course Interest Survey

by John M. Keller, Florida State University

1 = Not true 2 = Slightly true 3 = Moderately true 4 = Mostly true 5 = Very true

Please circle the number that corresponds to your feeling about lecture & laboratory for this course.

1. The instructor knows how to make us feel enthusiastic about the subject matter of this course.	1	2	3	4	5
2. The things I am learning in this course will be useful to me.	1	2	3	4	5
3. I feel confident that I will do well in this course.	1	2	3	4	5
4. This class has very little in it that captures my attention.	1	2	3	4	5
5. The instructor makes the subject matter of this course seem important.	1	2	3	4	5
6. You have to be lucky to get good grades in this course.	1	2	3	4	5
7. I have to work too hard to succeed in this course.	1	2	3	4	5
8. I do NOT see how the content of this course relates to anything I already know.	1	2	3	4	5
9. Whether or not I succeed in this course is up to me.	1	2	3	4	5
10. The instructor creates suspense when building up to a point.	1	2	3	4	5
11. The subject matter of this course is just too difficult for me.	1	2	3	4	5
12. I feel that this course gives me a lot of satisfaction.	1	2	3	4	5
13. In this class, I try to set and achieve high standards of excellence.	1	2	3	4	5
14. I feel that the grades or other recognition I receive are fair compared to other students.	1	2	3	4	5
15. The students in this class seem curious about the subject matter.	1	2	3	4	5
16. I enjoy working for this course.	1	2	3	4	5
17. It is difficult to predict what grade the instructor will give my assignments.	1	2	3	4	5
18. I am pleased with the instructor's evaluations of my work compared to how well I think I have done.	1	2	3	4	5
19. I feel satisfied with what I am getting from this course.	1	2	3	4	5
20. The content of this course relates to my expectations and goals.	1	2	3	4	5
21. The instructor does unusual or surprising things that are interesting.	1	2	3	4	5
22. The students actively participate in this class.	1	2	3	4	5
23. To accomplish my goals, it is important that I do well in this course.	1	2	3	4	5
24. The instructor uses an interesting variety of teaching techniques.	1	2	3	4	5
25. I do NOT think I will benefit much from this course.	1	2	3	4	5
26. I often daydream while in this class.	1	2	3	4	5
27. As I am taking this class, I believe that I can succeed if I try hard enough.	1	2	3	4	5
28. The personal benefits of this course are clear to me.	1	2	3	4	5
29. My curiosity is often stimulated by the questions asked or the problems given on the subject matter in this class.	1	2	3	4	5
30. I find the challenge level in this course to be about right: neither too easy not too hard.	1	2	3	4	5
31. I feel rather disappointed with this course.	1	2	3	4	5
32. I feel that I get enough recognition of my work in this course by means of grades, comments, or other feedback.	1	2	3	4	5
33. The amount of work I have to do is appropriate for this type of course.	1	2	3	4	5
34. I get enough feedback to know how well I am doing.	1	2	3	4	5

Appendix B

Background Factors and Personal Experiences Questionnaire

Record the LAST 4 DIGITS of Student # ________________Course Code_________

Biology Students Demographic, Educational History, and Affect Survey

1. What is your age? ________ *If you are 17 years old, please terminate participation now.

2. What is your gender? Male or Female (Circle one)

3. Where were you born (country)____
4. What is your ethnic background? ____

5. Are you a full-time or part-time student? (Circle one.)

6. What is your current declared major? ____

7. What is your ultimate career goal, meaning after all of your education is finished what is the job that you would love to have and that you are working towards? ___________________________

8. Are you a parent? YES or NO (Circle one).

9. Do you have a job outside of the home? YES or NO. Have multiple jobs? YES or NO. How many? _

10. Do you already hold a college degree? YES or NO (Circle one). If so, what is it?____________
____

11. What science courses did you take in high school? Please circle all that apply:

A. Biology/Living Environment	F. Anatomy and Physiology
B. Chemistry	G. Environmental Science
C. Physics	H. Marine Science
D. Earth Science	I. Forensic Science
E. Computer Science	J. Other (Please list)______________________

12. Did you ever do any type of science research project in high school? YES or NO (Circle one)

13. Do you feel that you understand what science research is really like? YES or NO (Circle one)

Circle the one answer that best describes your feeling for the next six statements:

14. My high school science courses had a negative effect on my major and career goal.
Strongly agree Agree Neutral Disagree Strongly disagree

15. My high school science courses were NOT interesting to me.
Strongly agree Agree Neutral Disagree Strongly disagree

16. My high school science courses were fun.
Strongly agree Agree Neutral Disagree Strongly disagree

17. My high school science courses properly prepared me for my community college courses?
Strongly agree Agree Neutral Disagree Strongly disagree

18. When I was in high school, I was made aware of what science, technology, engineering & mathematics (STEM) careers were available for me to study in college.
Strongly agree Agree Neutral Disagree Strongly disagree

19. Low cost of tuition was the main reason that I chose to attend a community college.
Strongly agree Agree Neutral Disagree Strongly disagree

20. For each of the following reasons, please circle your appropriate feeling. My decision to attend a community college was affected by:

A. Small class size
Strongly agree Agree Neutral Disagree Strongly disagree

B. Cost effective/affordable
Strongly agree Agree Neutral Disagree Strongly disagree

C. Community college being close to home
Strongly agree Agree Neutral Disagree Strongly disagree

D. Unsure if I could succeed at a 4-year college/university
Strongly agree Agree Neutral Disagree Strongly disagree

E. I didn't get accepted into a 4-year college/university
Strongly agree Agree Neutral Disagree Strongly disagree

F. My parents didn't allow me to apply to other schools
Strongly agree Agree Neutral Disagree Strongly disagree

G. I didn't feel confident enough to apply to a 4-year college/university
Strongly agree Agree Neutral Disagree Strongly disagree

21. For each of the following reasons, please circle your appropriate feeling. The reason that I decided to register for this biology course is:

A. I am interested in biology and the things that I might learn
Strongly agree Agree Neutral Disagree Strongly disagree

B. It is an elective for my major
Strongly agree Agree Neutral Disagree Strongly disagree

C. I want to know how my body works
Strongly agree Agree Neutral Disagree Strongly disagree

D. Pre-requisite for applying to nursing or some other health-related program
Strongly agree Agree Neutral Disagree Strongly disagree

E. I am a biology major and it is a requirement for my major
Strongly agree Agree Neutral Disagree Strongly disagree

F. It is the only class that could fit into my schedule and the time that I have available
Strongly agree Agree Neutral Disagree Strongly disagree

22. For each of the following reasons, please circle your appropriate feeling. My main motivation for selecting my current career goal was/is:

A. Projected future income (the money that I will make)
Strongly agree Agree Neutral Disagree Strongly disagree

B. My interest in science
Strongly agree Agree Neutral Disagree Strongly disagree

C. I think I will enjoy helping people, and my career will help me to do that
Strongly agree Agree Neutral Disagree Strongly disagree

D. Family or parental expectations
Strongly agree Agree Neutral Disagree Strongly disagree

23. For each of the following reasons, please circle your appropriate feeling. This background factor in my life had influenced my current career choice:

A. My ethnic background/culture strongly values education
Strongly agree Agree Neutral Disagree Strongly disagree

B. Supporting my children
Strongly agree Agree Neutral Disagree Strongly disagree

C. My parents said that it would be a good choice
Strongly agree Agree Neutral Disagree Strongly disagree

D. I can finish a degree at a community college in 2 years rather than 4 years
Strongly agree Agree Neutral Disagree Strongly disagree

E. It's what I have always wanted to do
Strongly agree Agree Neutral Disagree Strongly disagree

F. I really enjoy science
Strongly agree Agree Neutral Disagree Strongly disagree

G. I want to help others
Strongly agree Agree Neutral Disagree Strongly disagree

H. I want to make a lot of money
Strongly agree Agree Neutral Disagree Strongly disagree

I. I think I will be easy to obtain a job
Strongly agree Agree Neutral Disagree Strongly disagree

J. I want job security (people will always get sick/need health care)
Strongly agree Agree Neutral Disagree Strongly disagree

24. If the amount of money that you have was not a factor, do you think that you might have chosen a different career (meaning, I am shooting for nursing school rather than to be a doctor because I know that I don't have enough money to even dream of going to medical school or physicians assistant school, even though that is what I REALLY want to do)? YES or NO (Circle one)

25. Why didn't you enroll in more science courses in high school? (Please circle all that apply)
A. The thought of taking Regents exams turned me off from enrolling in more high school sciences
B. I am not good at math so I feel like I can't do science
C. I have always felt like I am not good at science
D. Science is too hard for me
E. I don't know what its about so I don't even feel like trying it
F. I didn't need to in order to graduate, so I didn't
G. None of the above/other ___________________________

26. Do you feel that you spend enough time studying? YES or NO (Circle one). If not, what prohibits you from studying more? (Please circle ALL that apply)

A. My job(s)
B. My obligations as a parent
C. My obligations as a care-taker for a parent or grandparent
D. My social life/dating is more important
E. I am not motivated to study because this subject is not interesting to me
F. I am too tired from my other responsibilities
G. I don't really want to go to college, but my parents are forcing me
H. I never really had to study in high school so I am not used to having to do it
I. None of the above/other ___________________________

Thank you for your participation! We will appreciate it. If you would like to be available for further questions during an interview process and receive a small gift card if you are selected to participate in an interview, please list your contact information below.

Name____

Phone Number ____

Email Address (please print very clearly)____

Appendix C

Introduction to the Survey

IRB Approved: 08/25/2014
Expiration Date: 08/24/2017
CORIHS Stony Brook University

Script for introduction to the survey:

Good morning/afternoon/evening students. Thank you for allowing me to speak with you today. First of all, I would like you to know that what I am about to ask you to do will in no way affect your grade for this class. Voluntarily participation in this survey may be helpful to the college and program development for students in the future, so, your open and honest answers are very much appreciated. This survey is being conducted for my doctoral research at Stony Brook University. I am very interested in finding out about your motivation and your interest in science and your educational needs.

Again, I remind you that your participation is completely voluntary. It is completely fine if you choose not to participate in this research study. Either way, if you participate or not, your grade in this course will NOT be affected in anyway.

If you are comfortable in sharing further information with me about your educational experiences in science prior to arriving at college and also while enrolled in college courses, I am also very interested in hearing what you would have to tell me. If you are interested in making yourself available for an interview, please include your phone number and email address at the very end of this form. If you are selected to participate in an interview, you will be awarded a small gift card for volunteering your time.

An important aspect of this study is also that I will get to survey you again at the end of the semester to see how your answers have changed. It is very important that I be able to link your survey results from now to the survey results at the end of the semester. Please enter the last 4 digits of your student ID number in the area on the survey forms that are provided. If you do not know your student ID number or have your student ID card, your instructor can help you to look it up on the class roster.

Please make sure to answer all questions fully and completely. If any questions are not answered then your survey may not be able to used as part of the study, so please make sure that you have answer all questions on both sides of the paper if you are participating.
Once again, thank you for your time. I appreciate your honesty and for being a part of this study that will be very helpful for your future SCCC classmates. When you have completed both sheets front and back please bring them to me as I will be waiting in the front/back of the ***room.***

Appendix D

Script for Semi-Structured Interviews

Interview script for the community college students enrolled in a biology course

1. What and when are your earliest memories of science?	
2. Can you remember when you first started liking science?	
3. What or who inspired you to feel like you might want to study science or have it be a part of your career?	
4. Do you ever remember an instance when someone told you that science might not be right for you?	
5. How do you feel about mathematics? Did you ever worry about math skills hurting your ability to study science?	
6. Why did you choose to study science/enroll in this science course specifically at Suffolk Community College?	
7. Do you feel that the community college gives you more attention and helps you to learn better than a four-year college or university? Please explain.	
8. Do you feel like this class that you have taken at community college have changed your idea of science? Please explain how.	
9. Do you feel like the classes that you have taken at community college have changed your career goal? Please explain how.	
10. How much influence do you feel that the instructor in this course has had on your interest in science? On your confidence in relation to this science course? And, your motivation to study science?	

11. How much influence do you feel that your parents had on your career goal/motivation to study science? What about your family now: spouse/significant other/children?	
12. How much influence do you feel that your cultural background had on your career goal/motivation to study science?	
13. How much influence do you feel that your elementary school teachers had on your career goal/motivation to study science?	
14. How much influence do you feel that your middle school teachers had on your career goal/motivation to study science?	
15. How much influence do you feel that your high school teachers had on your career goal/motivation to study science?	
16. Did the idea of having to take a Regent's exam influence the choice of courses you wanted to take in high school?	
17. Do you think science is fun?	
18. Do you think you would be more motivated to study science if it were fun?	
19. What is the most influential factor in your life that motivates you to study science?	
20. Do you think that you will love your career once you reach the goal? How important is your happiness? Is it more important than money?	
21. Did the socioeconomic status of your family when you were a child affect your dreams and career aspirations? How so?	
22. Is there anything else about your experience in this class or your past education that you want to tell me that I haven't asked about?	

Appendix E

Interview Consent Form

IRB Approved: 08/25/2014 Expiration Date: 08/24/2017 CORIHS Stony Brook University

Stony Brook University

Committees on Research Involving Human Subjects Established 1971

RESEARCH CONSENT FORM

Project Title: Community College Students' Motivation to Study Science Principal Investigator: Angela M. Kelly, Ph.D. Co-Investigators: Hope M. Sasway

Department: Center for Science & Mathematics Education

You are being asked to be a volunteer in a research study.

PURPOSE

The purpose of this study is to identify factors that influence student interest, motivation, and confidence to enroll in science courses at the community college level. You are eligible for this study because you are a community college student whom is currently enrolled in a biology course at Suffolk County Community College or are a past BioPREP participant. There will be approximately 12-29 participants in this research study.

PROCEDURES If you decide to be in this study, your part will involve:

- a 30-45 minute interview regarding your attitudes toward science and motivation to study science, more specifically, biology, at the community college and your future career goals due to the influence of these factors.

- audiotaping of the interview, or if you prefer, the researchers will take field notes during the interview.

RISKS / DISCOMFORTS There are no foreseeable risks or discomforts associated with your participation in this study. Your grade in your biology course will NOT be affected.

BENEFITS

There is no benefit expected as a result of you being in this study.

PAYMENT TO YOU

Students will be offered a $10 gift card to Starbucks or Target if they are chosen to and participate in an interview process.

CONFIDENTIALITY Protecting Your Privacy in this Study

We will take steps to help make sure that all the information we get about you is kept private. Your name will not be used wherever possible. We will use a code instead. All the study data that we get from you will be kept locked up. The code will be locked up too. If any papers and talks are given about this research, your name and the name of the school district will not be used. All audiotapes of interviews will be deleted after transcription.

We want to make sure that this study is being done correctly and that your rights and welfare are being protected. For this reason, we will share the data we get from you in this study with the study team, Stony Brook University's Committee on Research Involving Human Subjects, applicable Institutional officials, and certain federal offices. However, if you tell us you are going to hurt yourself, hurt someone else, or if we believe the safety of a child is at risk, we will have to report this.

In a lawsuit, a judge can make us give him the information we collected about you.

COSTS TO YOU

There are no costs associated with participation in this study.

ALTERNATIVES

Your alternative to being in this study is to simply not participate.

YOUR RIGHTS AS A RESEARCH SUBJECT

• Your participation in this study is voluntary. You do not have to be in this study if you don't want to be.

• You have the right to change your mind and leave the study at any time without giving any reason, and without penalty.

• Any new information that may make you change your mind about being in this study will be given to you.

• You will get a copy of this consent form to keep.

• You do not lose any of your legal rights by signing this consent form.

QUESTIONS ABOUT THE STUDY OR YOUR RIGHTS AS A RESEARCH SUBJECT

• If you have any questions, concerns, or complaints about the study, you may contact Dr. Angela Kelly, (631) 632-9750, OR angela.kelly@stonybrook.edu.

• If you have any questions about your rights as a research subject or if you would like to obtain information or offer input, you may contact Ms. Judy Matuk, Committee on Research Involving Human Subjects, (631) 632-9036, OR by e-mail, judy.matuk@stonybrook.edu. If you sign below, it means that you have read (or have had read to you) the information given in this consent form, and you would like to be a volunteer in this study. Signature: Date Will you allow the interview to be audiotaped:

YES______ NO______ ____

Subject Name (Printed) ____

Subject Signature Date ____

Name of Person Obtaining Consent

(Printed) ____

Signature of Person Obtaining Consent Date

____

Appendix F

Course Code and Descriptions for the Classes Surveyed

Electives

1. *Principles of Biology*: A one-semester survey courses for non-biology majors. Key concepts include biological chemistry, cell structure and function, organization of multicellular organisms, genetics, evolution, and ecology (3 hours lecture, 2 hours laboratory).

2. *Introduction to Oceanography*: Life in the oceans is studied against a background of its interaction with the physical, chemical and geological environment. Lectures, laboratory and field trips explore fundamental properties, which underlie oceanic phenomena. For liberal arts and general studies students (3 hours lecture, 2 hours laboratory).

3. *Marine Biology*: Populations of animals and plants inhabiting Long Island's intertidal and near-shore environments are studied. Special attention given to the biology and natural history of these organisms. Community relationships and effects of abiotic environment on coastal populations also emphasized (3 hours lecture, 2 hours laboratory).

Majors' Courses

4. *Modern Biology I*: The course is a comprehensive study of the basic processes in living systems at the cellular and molecular levels of organization. Basic chemistry, aspects of cell structure, metabolism, cell energetics, and elements of classical and molecular genetics serve as the foundation for subsequent investigation of living systems. The principles of evolution underlie all discussions in the course. This course is the first semester of a two-semester sequence designed for science majors (3 hours lecture, 3 hours laboratory).

5. Modern Biology II: This course is a comprehensive study of the basic processes in living systems at the following levels of organization: prokaryotic and eukaryotic organisms, organs and organ systems of multicellular organisms. The course will emphasize contrasts and comparisons of living processes seen across the Domains of life. An emphasis on evolution and ecology will organize the contexts in which biosystematics, morphology and physiology are studied. This course is the second semester of a two-semester sequence designed for science majors (3 hours lecture, 3 hours laboratory).

6. *Microbiology*: An introduction to the study of microorganisms and their environments. Introduces students to microbial physiology, microbial genetics (including recombinant DNA technology), immunology, microbial ecology and evolution. Designed for science majors (3 hours lecture, 4 hours laboratory).

Service Courses

7. *Anatomy and Physiology I*: basic principles of the structure and function of the human body are discussed in depth for each of the organ systems. Physiology is presented from both a

biochemical and organismal point of view. Basic chemistry, physics and mathematics are introduced where useful and necessary for understanding these biological phenomena. Special attention is given to the application of the principles and concepts to health-related areas. First semester of a two-semester sequence (3 hours lecture, 3 hours laboratory).

8. *Anatomy and Physiology II*: Basic principles of the structure and function of the human body are discussed in depth for each of the organ systems. Physiology is presented from both a biochemical and organismal point of view. The endocrine, digestive, respiratory, urinary, immune, cardiovascular, and reproductive systems will be emphasized. Basic chemistry, physics, and mathematics are introduced where useful and necessary for understanding these biological phenomena. Special attention is given to the application of these principles and concepts to health-related areas. Second semester of a two-semester sequence (3 hours lecture, 3 hours laboratory).

9. *General Microbiology*: An introduction to microbiology through a survey of methods, tools and techniques used in studying main groups of bacteria and other microorganisms and application of this knowledge in physical and chemical control of microorganisms. The relationship of microorganisms to disease is discussed (3 hours lecture, 4 hours laboratory).

Programmatic Requirements

10. *Fundamentals of Human Structure and Function*: The human body as a wholly integrated, self-regulating model of functional anatomy. Introduces human structure at the cellular level and progresses to tissues, organs and organ systems. Common pathologic conditions are contrasted with normal form and function. (3 hours lecture, 2 hours laboratory).

11. *Zoology*: An evolutionary approach to a survey of animal kingdom. Topics include: the origin of life, cell structure and molecular biology. It also involves taxonomic study of structure and function of representatives of the major phyla as well as their ecology and life history. The vertebrate is covered in detail. Laboratory exercises parallel many of the lecture topics with emphasis on vertebrate dissection. (2 hours lecture, 2 hrs. laboratory).

Appendix G

Confidence, Interest and Motivation in Relation to Change in Course Interest

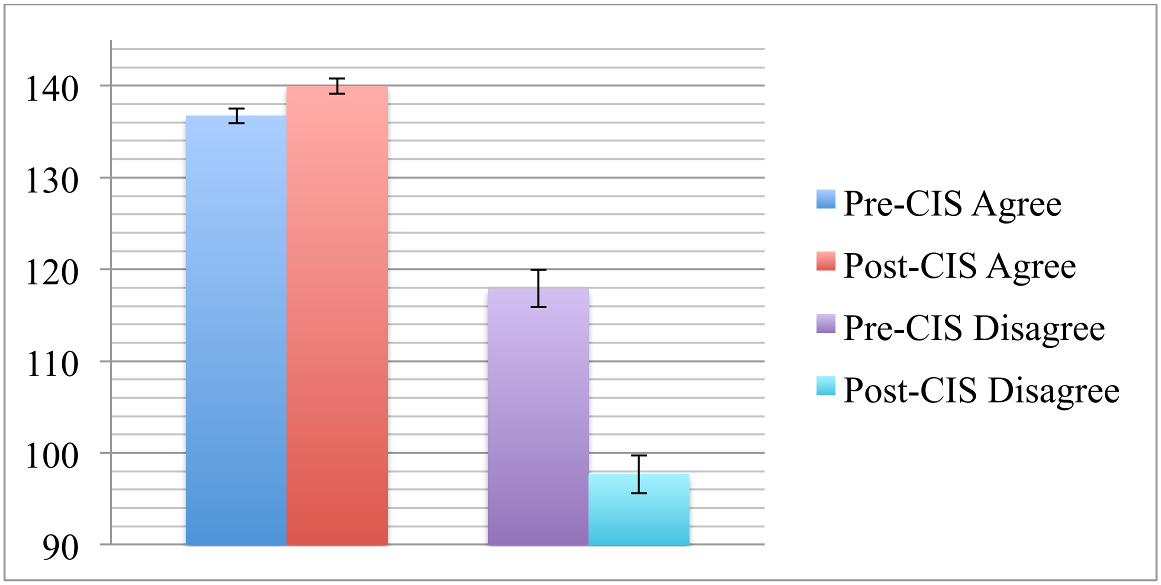

Figure G1. I feel more *confident* that I could successfully complete another biology course due to what I have learned this semester.

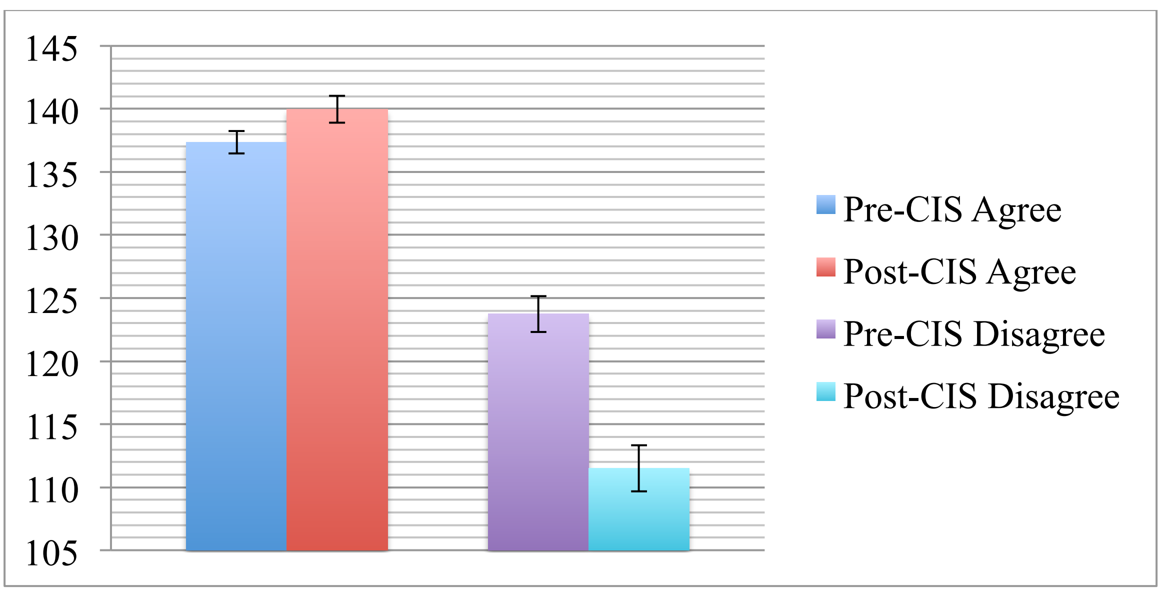

Figure G2. I am more *interested* in enrolling in another biology course due to what I have learned this semester.

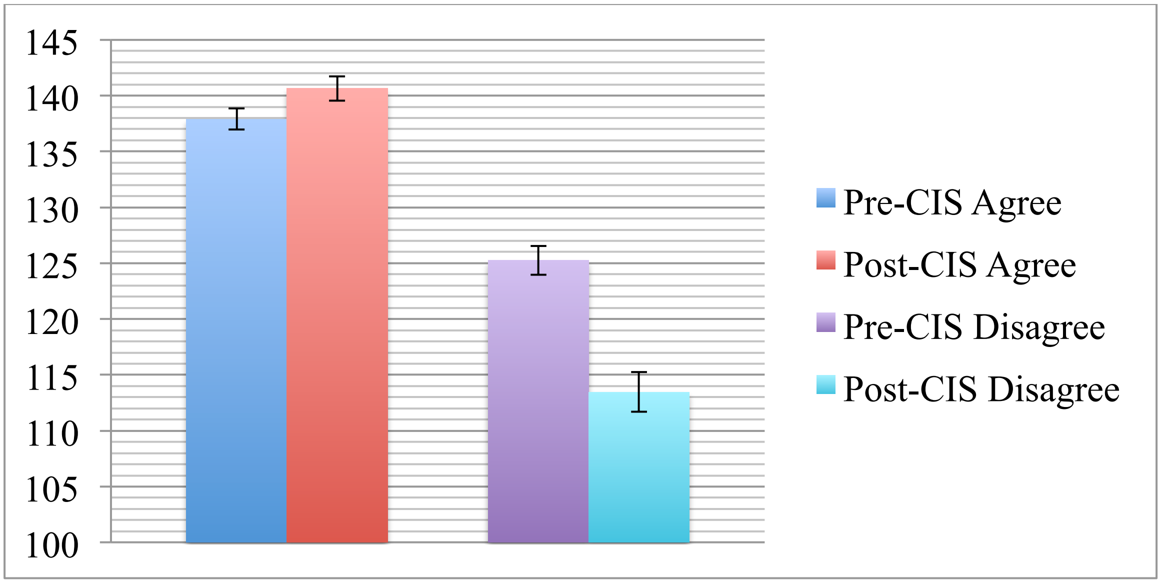

Figure G3. This course is *motivating* me to stay in or change to a science related career.

Appendix H

Students' Feelings about High School Science Related to Change in Course Interest

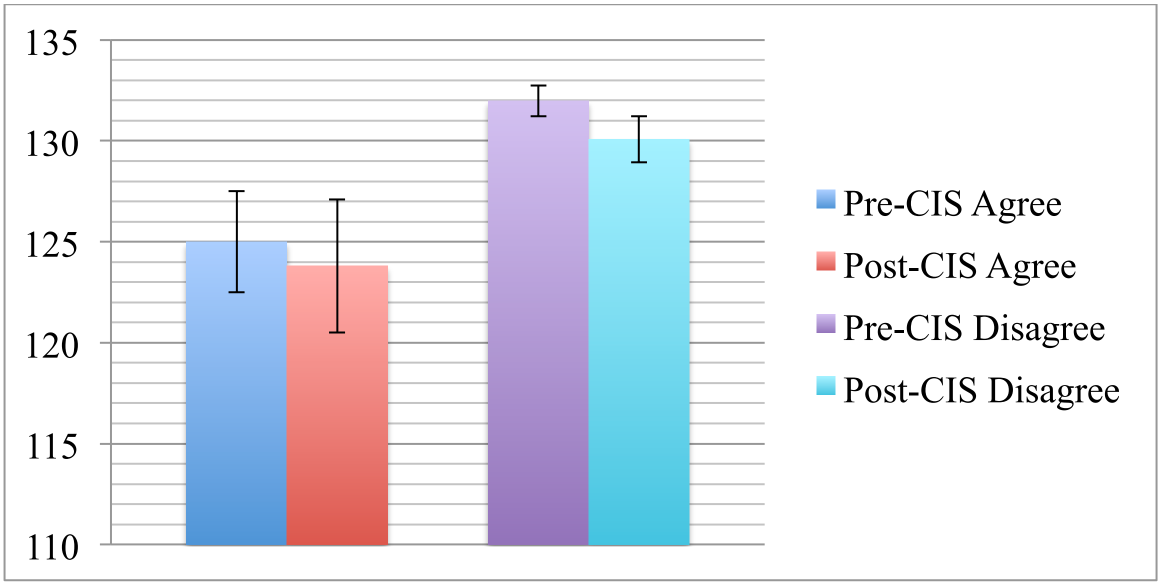

Figure H1. My high school science courses had a negative effect on my major and career goal.

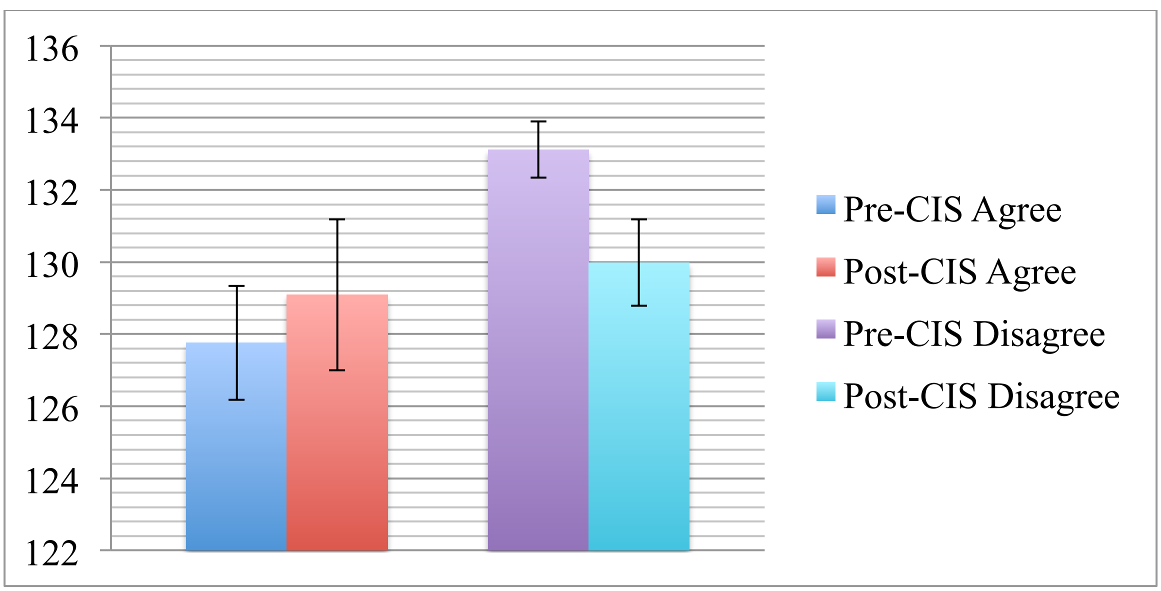

Figure H2. My high school science courses were not interesting to me.

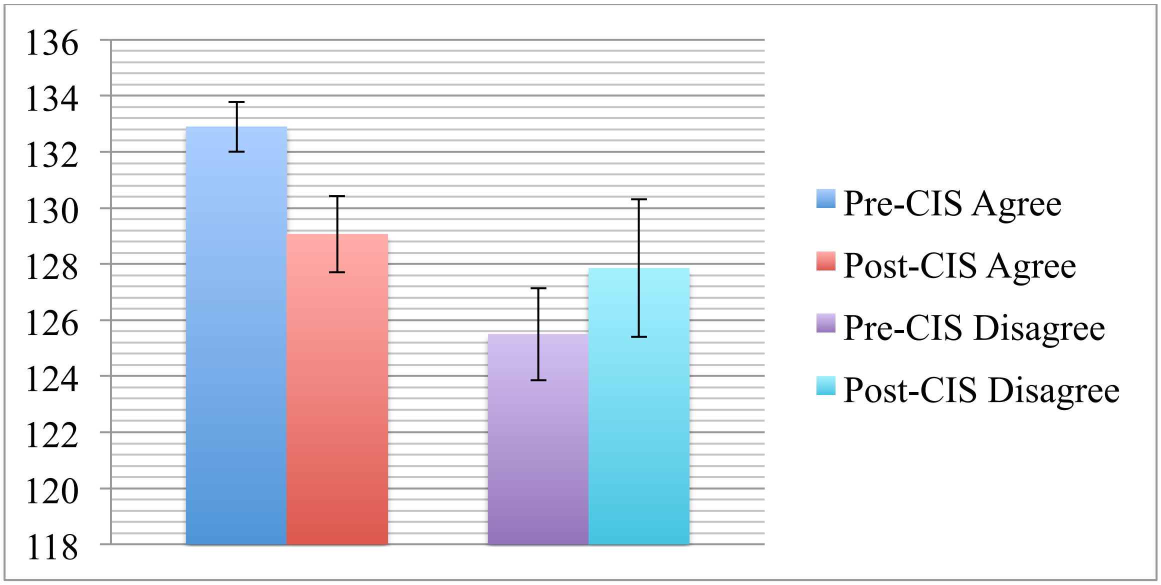

Figure H3. My high school science courses were fun.

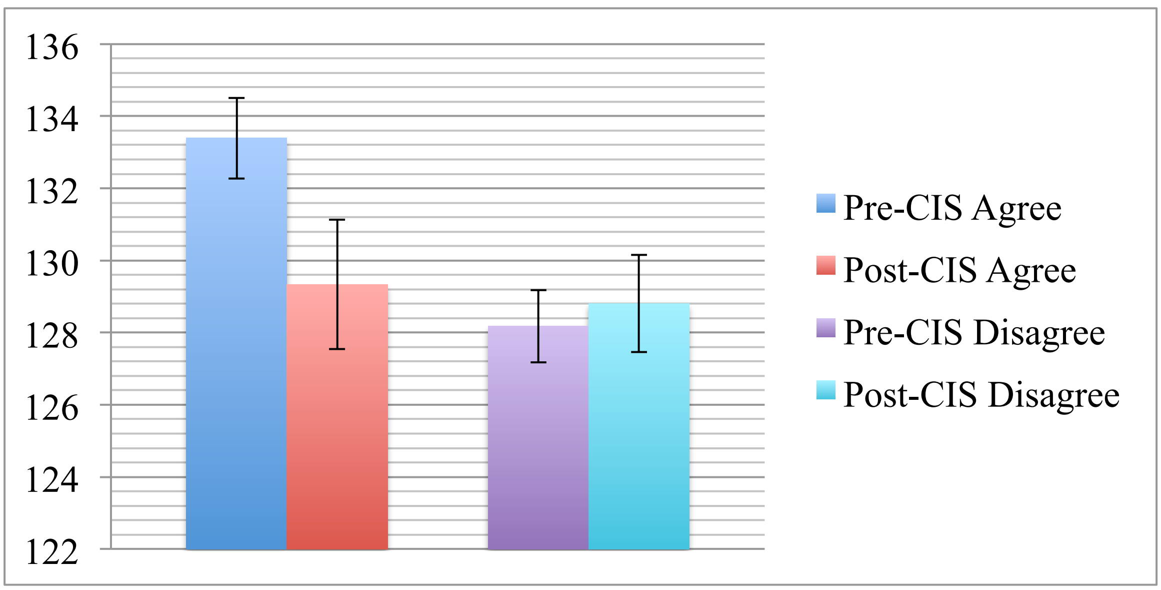

Figure H4. I was made aware of STEM careers were available to me to study in college.

Appendix I

Students' Course Choice Related to Change in Course Interest

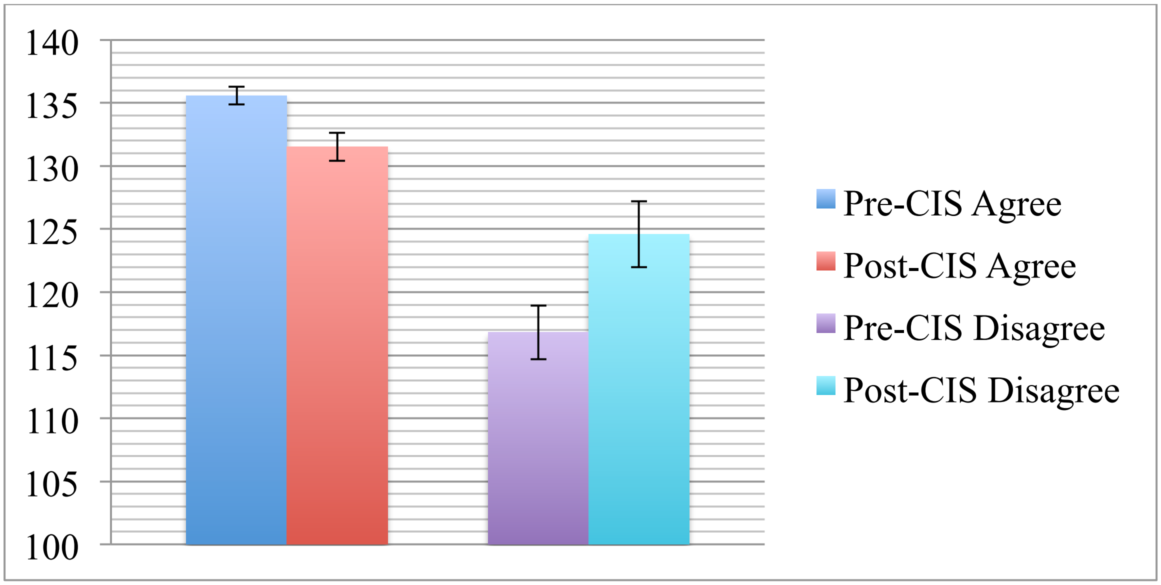

Figure I1. I registered for this course because I am interested in biology and the things that I might learn.

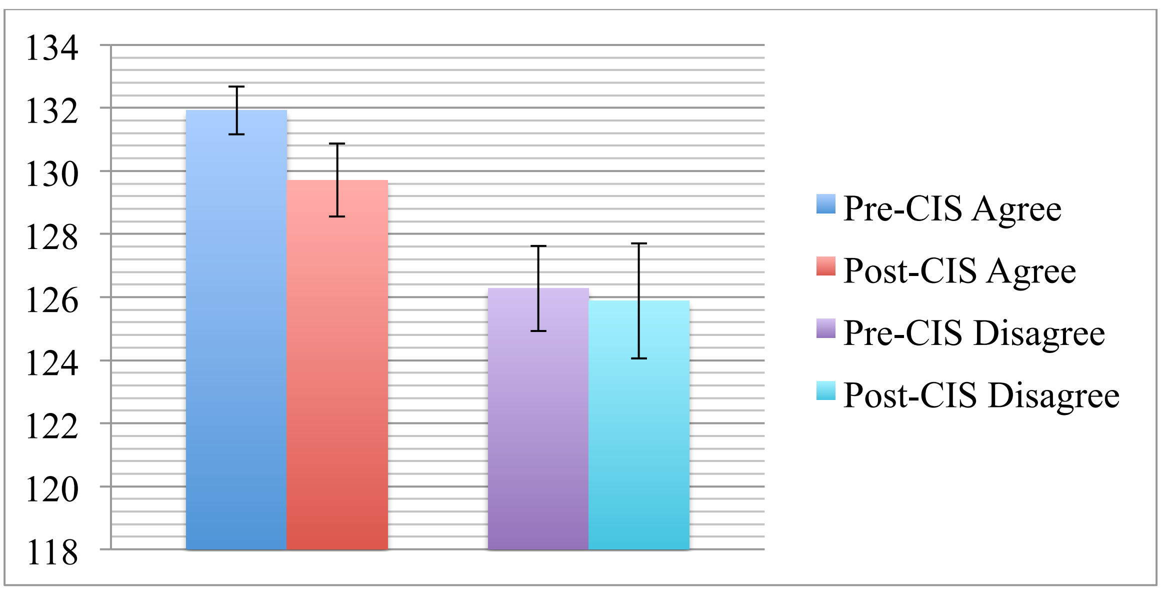

Figure I2. I chose this course because it is a pre-requisite for applying to nursing or a health related degree program.

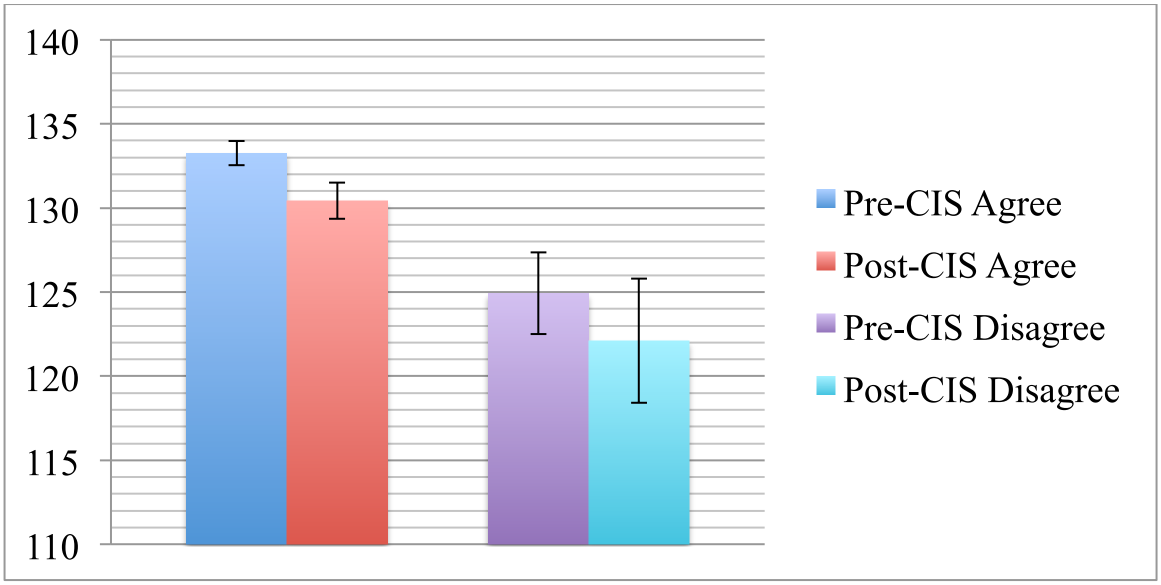

Figure I3. I chose this class because I want to know how my body works.

Appendix J

Main Motivation for Career Goals and Change in Course Interest

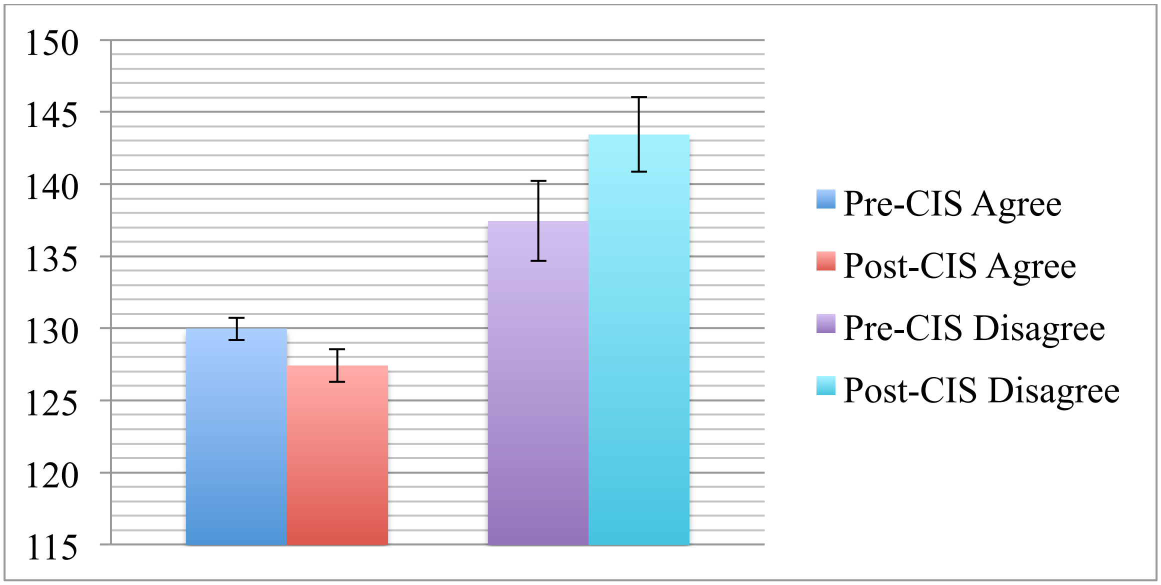

Figure J1. My main motivation for my career goal is that I want to make a lot of money.

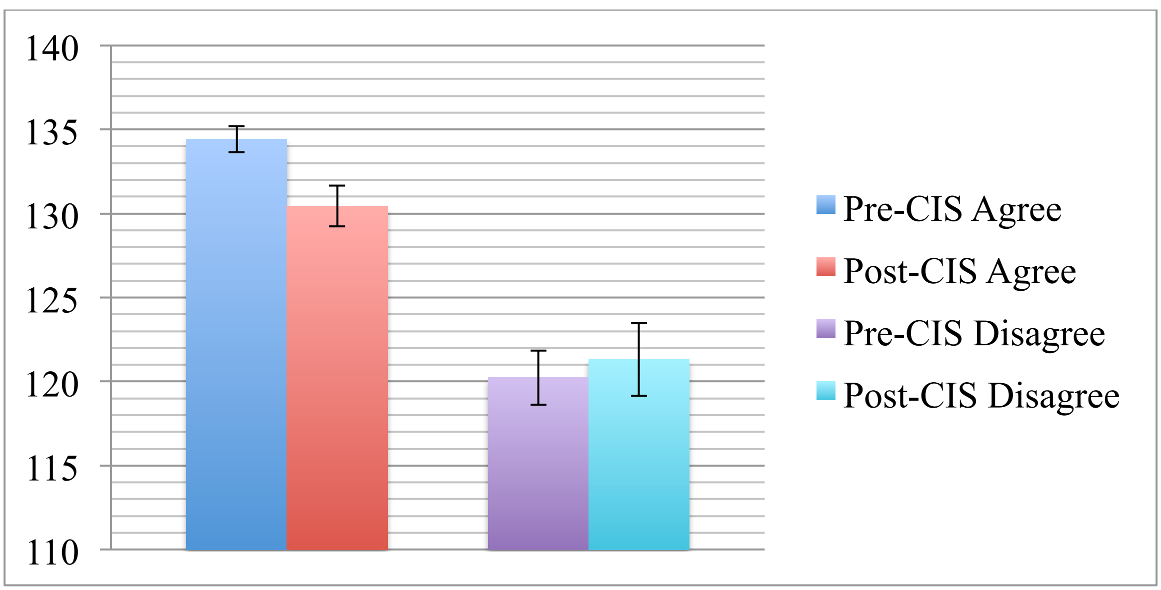

Figure J2. My main motivation for my career goal was my interest in science.

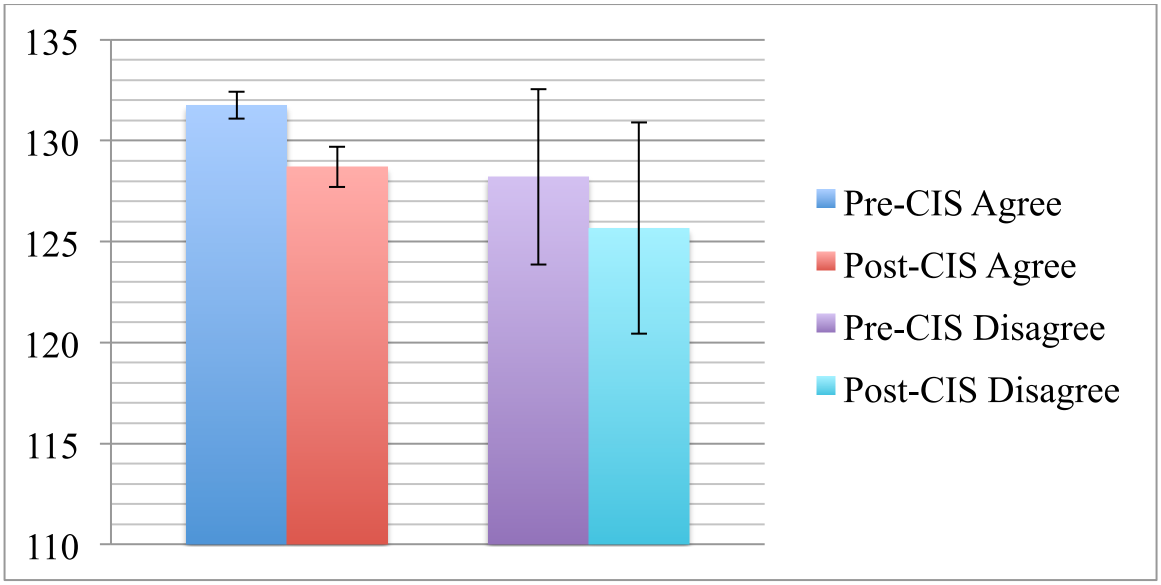

Figure J3. Main motivation for my career goal was that I enjoy helping people and my career will enable me to do so.

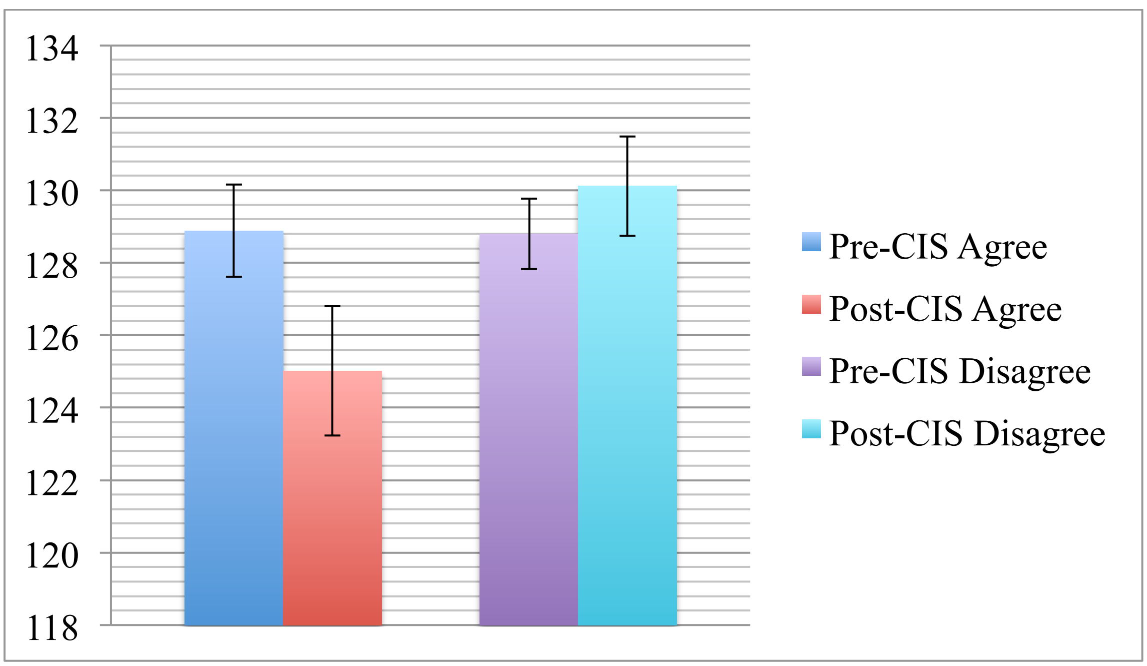

Figure J4. My main motivation for my career goal is family or parental expectations.

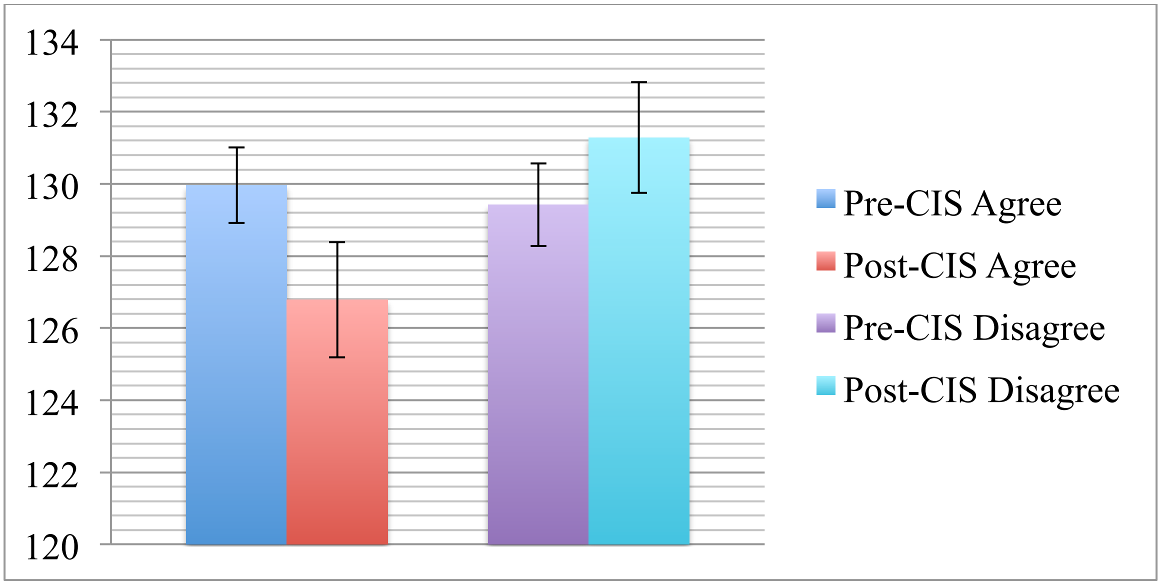

Figure J5. My parents said that this would be a good career choice and that influenced my motivation.

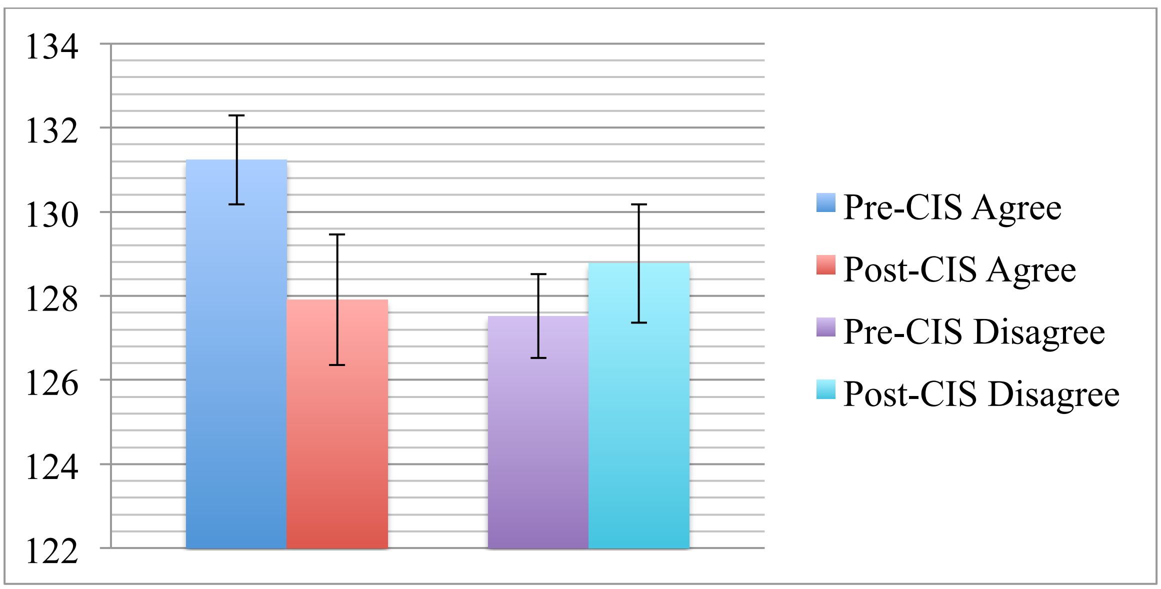

Figure J6. Supporting my children or the children I might have has influenced my career choice.

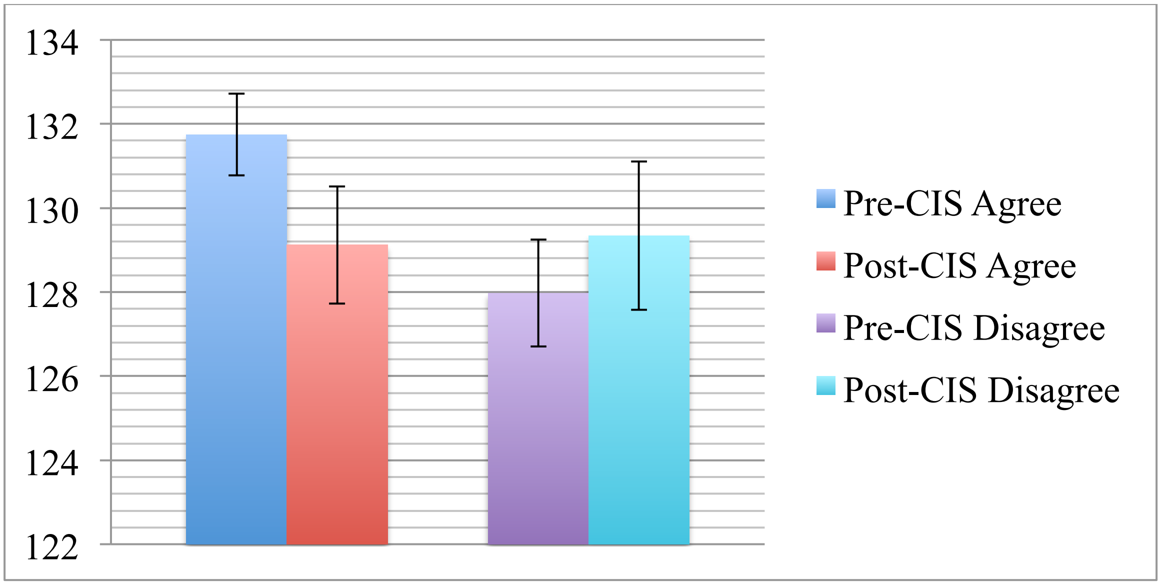

Figure J7. My ethnic background/culture strongly values education.

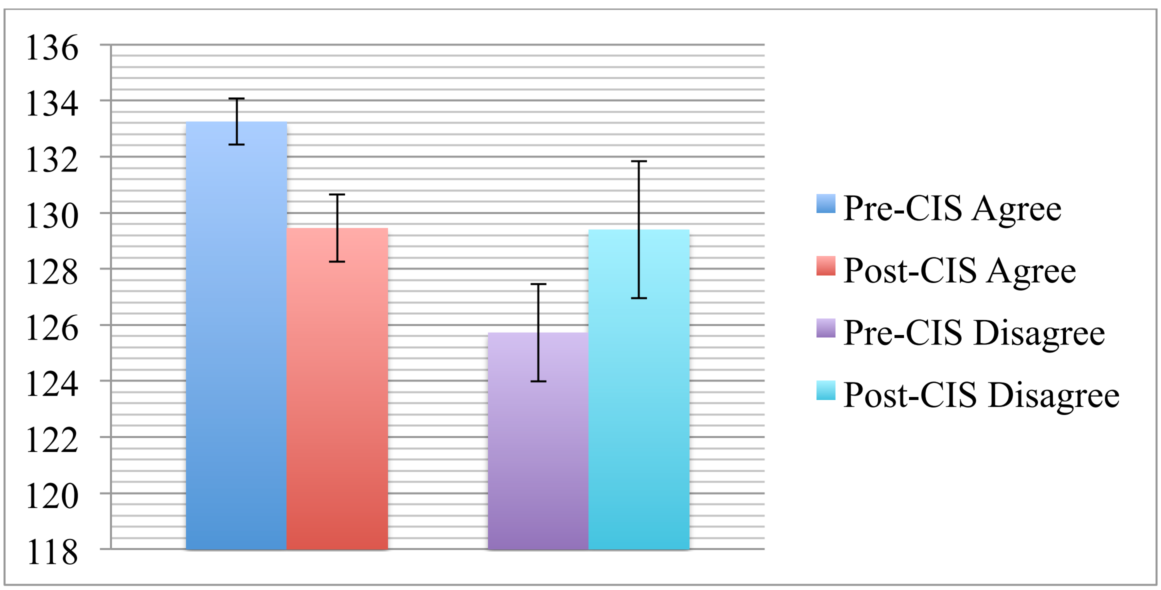

Figure J8. My main motivation for my career goal is that it what I have always wanted to do.

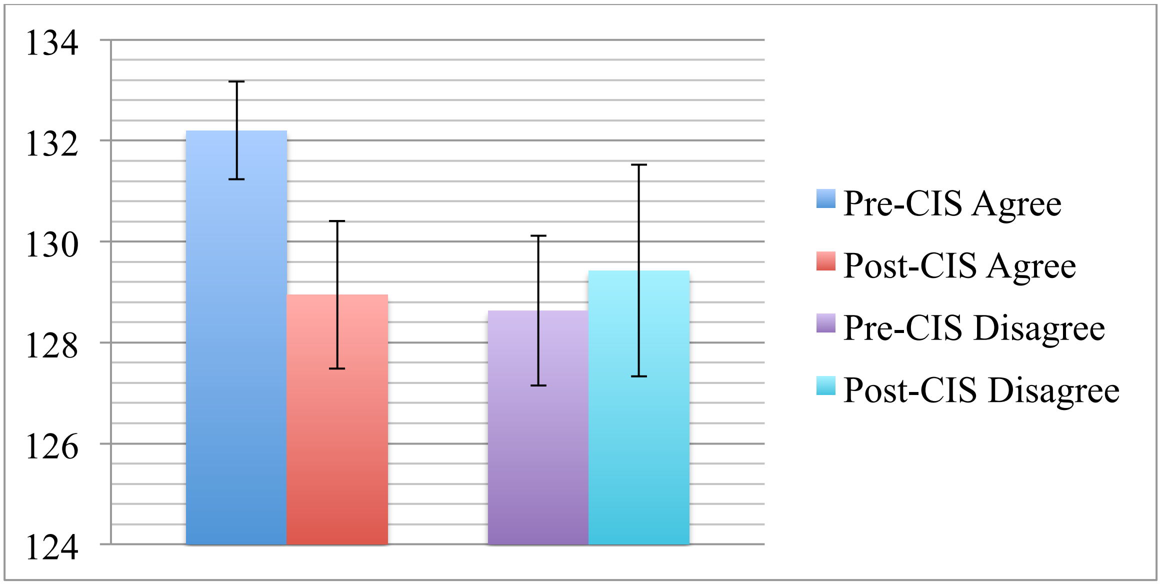

Figure J9. My main motivation for my career goal is that I think it will be easy to obtain a job.

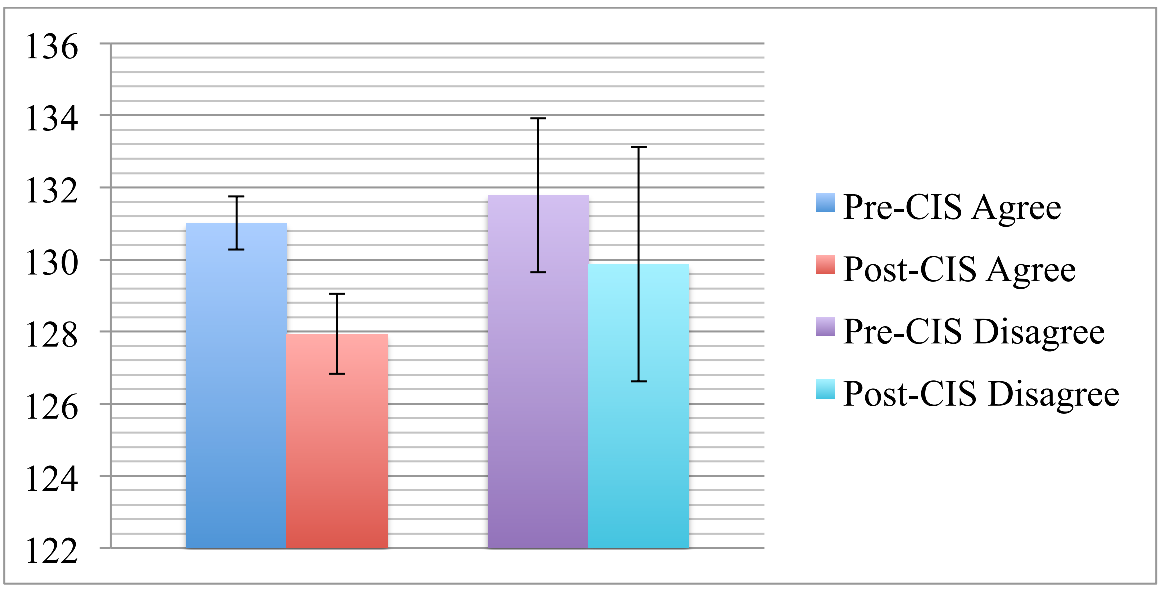

Figure J10. My main motivation for my career goal is that I want job security.