The Effect of Mathematics Anxiety on the Course and Career Choice of High School Vocational-Technical Education Students

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Dedications

I would like to dedicate this dissertation to my parents, Vincent and Dorothy Scarpello, who modeled for me the joy of learning and for their unflagging support.

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I would like to first thank my Chair, Dr. Sheila Vaidya whose guidance and direction ensured the completion of this study. I would also like to thank my dissertation committee: Dr. Craig Bach, Dr. Marion Dugan, Dr. Teck-Kah Lim, Dr. James Mc Dowelle, and Dr. Elizabeth Haslam for their insightful guidance in sharpening the focus of this work.

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Abstract

The Effect of Mathematics Anxiety on the Course and Career Choice of High School Vocational-Technical Education Students

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Sheila Vaidya, Ph. D.

Many students who suffer from mathematics anxiety have little confidence in their ability to do mathematics and tend to take the minimum number of required mathematics courses, greatly limiting their career choice options. This is unfortunate, especially as our society becomes more reliant on mathematical literacy. This study investigated whether course and career choices were affected by mathematics anxiety. The subjects of this study were suburban 9th grade vocational-technical education high school students from southeastern Pennsylvania.

Although the study acquired only a small sample size, limiting the study's generalizability, the data from the student interviews and questionnaires provided the following results. There was a negative correlation between mathematics anxiety and career efficacy. More than half of the students had moderate to high levels of mathematics anxiety and scored below the 50th percentile on the Career Choice Survey indicating low mathematics and career efficacy.

Fifty-six percent of the students reported that they did not enjoy performing the career related mathematics required by their vocational-technical education lab curriculum. There was an increase in the number of students enrolled in below level courses in 9th grade from 8th grade. Students who demonstrated low mathematics anxiety tended to be enrolled in vocational-technical education labs requiring higher

mathematical ability. These students also did well in their mathematics courses in elementary, middle/junior high and high school. Whereas, the students in the labs that did not require high-level mathematics ability tended to have significant levels of mathematics anxiety and reported that as they progressed through middle/junior high school, they were losing confidence in their ability to be successful in their academic mathematics courses.

There was strong parental support for the students' choice of career-related vocational-technical education courses, but very little parental support was given to the students to pursue academic mathematics courses.

Recommendations from the study: Increased parental encouragement to pursue mathematics and the use of teaching methodologies that lessen mathematics anxiety in the student.

Chapter 1: Introduction

"The mathematical ignorance of our citizenry seriously handicaps our nation in a competitive and increasingly technological global marketplace" (Battista, 1999 p. 426). According to the National Research Council, 75% of Americans stop studying mathematics before they have completed the educational requirements for their career or job (Battista, 1999 p. 426). Why do students shy away from taking mathematics in school? How does this avoidance of mathematics affect their career choice?

What brought me to this research was my classroom experience as a mathematics teacher at a vocational-technical education high school. I found the students I was teaching had a dislike for and fear of mathematics. Many of these students had performed poorly in previous mathematics courses and many were not prepared for the mathematics course in which they were enrolled. Many had either not mastered the prerequisite academic mathematics course(s) or did not have the prerequisite academic course(s) but instead had consumer mathematics or equivalent course(s). Observing student reactions to mathematics I began to wonder if this was having an effect on their choice of vocational lab at the vocational-technical education school.

Results of testing conducted by the National Assessment of Educational Progress indicated that only 13% to 16% of 12th-graders were proficient in mathematics (Battista, 1999). The National Research Council found that 60% of students enrolled in college mathematics courses were enrolled in courses that were taught in high school (Battista, 1999). The mathematical competency of the workforce is so important that businesses are spending more on remedial mathematics for their employees than the combined expenditures by schools, colleges, and universities on mathematics education (Battista, 1999).

Today's job market increasingly relies on a highly technically trained workforce (Bleyer, Pedersen, & Elmore, 1981) with almost 75% of the jobs in the future requiring computer use (Shoffner & Vacc, 1999). These technical positions demand mathematical competence. If the student lacks the necessary mathematical background to pursue these technical careers, their career choices will be limited in the future.

The focus of this research is to investigate the effect of mathematics anxiety on the course and career choice of high school vocational-technical education students, and whether there is a difference in this effect based on gender. Research indicates that many factors influence a student's career decision. Some factors may have more weight than others in the career choice process: especially social and economic factors (Lent, Brown, & Hackett, 1994), gender-role identification (Singer & Stake, 1986), influences from parents (Kotrlik & Harrison, 1987; Otto, 2000; Phillips & Imhoff, 1997), and peers (Auster & Auster, 1981; Kotrlik & Harrison, 1987; Lent et al., 2002). However, little research has been conducted on just how significant mathematics anxiety is in effecting course and career choice of high school vocational-technical education students.

1.1 The Effect of Mathematics Anxiety on Course and Career Choice

Mathematics anxiety may be a critical factor in the educational and vocational choices students make and may influence whether or not they achieve their educational or career goals (Betz, 1978). One educator states "When otherwise capable students avoid the study of mathematics, their options regarding careers are reduced, eroding the country's resource base in science and technology" (Hembree, 1990 p. 34). The amount of mathematics taken in high school and college determines a student's range of career options (Lent, Lopez, & Bieschke, 1993). To have a broad range of career options, students need to be adequately prepared in mathematics (Hackett, 1985) or they will be blocked from many occupations (Steele & Arth, 1998). If high school students do not take algebra for example, they will be limiting their career options because algebra is a prerequisite for many other mathematics or science courses (Fleischner & Manheimer, 1997).

Mathematics anxiety influences both directly and indirectly the choice of major based on the amount of mathematics required (Hackett, 1985). Chipman, Krantz, & Silver (1992) found that entering college students who are severely mathematics anxious may enroll in majors that require minimal courses in mathematics such as majors in the humanities, the arts, and social sciences rather than enrolling in more mathematically oriented majors such as the sciences or engineering (Zettle & Raines, 2000).

Studies have shown that the higher the level of mathematics anxiety, the more likely is the student to avoid mathematics-related tasks, courses or careers

(Betz, 1978; Zettle & Houghton, 1998). Waldington, Austin & Bitner (1983), found that people who have poor mathematics attitudes are fearful of mathematics or have intense negative emotions about anything remotely dealing with mathematics (Sherman & Christian, 1999). Whereas high achieving students in mathematics have low anxiety (Aiken, 1970, 1976; Clute, 1984; Crosswhite, 1972; Hendel, 1977; Richardson & Suinn, 1972). Fennema (1980) found that there is an undeniable relationship between mathematics anxiety and mathematics-related performance and between mathematics anxiety and career choice (Hackett, 1985).

1.2 The High School Vocational-Technical Education Student

There have been many studies that have investigated the academic course and career choice of college students and its relationship to mathematics anxiety (Hembree, 1990; Ma, 1999; Wulff & Steitz, 1997), but few studies have been conducted involving secondary vocational-technical education students (Slaats, Lodewijks, & van der Sanden, 1999). High school vocational-technical education students have unique career decision-making patterns (Kotrlik & Harrison, 1987). The content of high school college preparatory curriculum is quite different from that of vocational-technical education curriculum. Students pursue one or the other curriculum based on different career interests (Koski & Subich, 1985).

Some students have been persuaded to select high school vocational-technical education due to many years of unsuccessful educational experiences, which has convinced them not to aspire to college and to avoid those occupations that require college degrees (Lewis, 2000). Many high school vocational-technical education students do not like academic subjects, and find the learning environment of vocational classes to be more comfortable than that of the typical academic classroom (Lewis, 2000).

Unfortunately, many students stop taking mathematics courses by the 10th grade and this significantly limits their career choices (Lent et al., 1993). The high school vocational-technical student tends to be less prepared in the number and level of mathematics courses taken (Dick & Rallis, 1991) and typically enters the labor market earlier than the college bound student (Grimes & Scalise, 1987). Since high school vocational-technical education students tend to dislike academic subjects such as mathematics, and do not enjoy pursuing careers requiring a college degree, they will have limited their career options.

Research investigations show that there are many factors that influence course and career choice. One such factor is a student's gender-role identification; for example, women are less likely than men to select a mathematics-related career (Singer & Stake, 1986). Mathematics avoidance in adolescent and adult women appears to be deeply rooted in sex-role socialization (Tobias, 1981). For men mathematics efficacy is seen as successfully fulfilling masculine sex-role expectations but for women mathematics efficacy does not successfully fulfill feminine sex-role expectations. Success in mathematics has a much different meaning for men and women (Singer & Stake, 1986). Not only can a student's gender-role identification influence course and career choice; but also, as Tobias (1978) found, peers' and teachers' attitudes toward gender and ethnicity may increase or decrease their confidence in mathematical skills (Stuart, 2000).

Bandura (1977) believes that "verbal persuasion" (p. 202) can impact a person's self-efficacy based on how the person perceives the "credibility of the persuaders, their prestige, trustworthiness, expertise, and assuredness" (p. 202). The more the person believes in the veracity of the persuader, the more likely the person is to change their self-efficacy expectations (Bandura, 1977). Because adolescents depend on their peers to provide validation of their personal worth, peers can influence adolescent career choice (Auster & Auster, 1981).

Hilton (et al., 1991) and Ware & Lee (1988) found that parents have a greater influence than teachers and counselors on adolescent career aspirations (Farmer, Wardrop, Anderson, & Risinger, 1995). It has been found that the family directly influences career choice, opportunities, and expectations (Auster & Auster, 1981) with mothers being the most important person adolescents talk to concerning course and career choice (Otto, 2000). Parental encouragement also directly affects grades and outcome expectancies in mathematics and science (Ferry, Fouad, & Smith, 2000). According to some studies, a student's attitude toward mathematics was positively related to their parent's attitude toward mathematics (Aiken, 1970; Ferry et al., 2000) which subsequently affects their levels of confidence (Stuart, 2000). Students have higher grades in mathematics when they perceive that their parents are encouraging their effort in mathematics (Ferry et al., 2000; Stuart, 2000).

1.3 Theoretical Perspective

The theoretical framework for this study is derived from Bandura's general social cognitive theory. Social cognitive theory applied to career psychology focuses "on the role of self-efficacy beliefs in vocational and academic interest, choice, and performance" (Lent et al., 1994 p. 109). In this theory, a person's choice of behavior and how much effort they will expend and for how long they will sustain that effort in spite of obstacles and adverse experiences (demonstrating persistence) is governed by one's perception of self-efficacy (Bandura, 1977). A person will have lower performance (efficacy) expectations if they believe that they are not able to be successful due to personal inadequacies rather than due to the particular situation they find themselves to be in (Bandura, 1977). Self-efficacy expectations are independent of performance (Bandura, 1977) and are a better predictor of behavior than is the actual capability of the person (Pajares & Miller, 1995).

Bandura (1989) defines efficacy beliefs as "the product of a complex process of self-persuasion that relies on cognitive processing of diverse sources of efficacy information" (p. 1178). These sources of efficacy information include performance mastery, watching others to see how the person's capabilities measure up, verbal persuasion and other social influences from others that indicate the person's capabilities (Bandura, 1989).

If students judge that they do not have the confidence to be successful, they will avoid potentially threatening situations and activities by adopting defensive behaviors such as avoidance even if they are not anxious at that particular moment (Bandura, 1989). This "defensive behavior", according to Bandura (1977) is maintained because it is successful in reducing anxiety-causing events like enrolling in mathematics courses. This avoidant behavior is difficult to eliminate even if the threat no longer exists (Bandura, 1977). Thus, the student's defensive behaviors may have become so successful in avoiding mathematics courses that over time his or her level of mathematics anxiety may have been greatly reduced or even eliminated because the threat of taking future mathematics courses has been eliminated. Since the student's mathematics anxiety has been reduced, the mathematics avoidance behavior is reinforced.

Students who were mathematics anxious in elementary and or middle school may not be mathematics anxious in high school if they were successful in avoiding mathematics courses they viewed as potentially threatening in middle/junior and high school. These students who no longer suffer from mathematics anxiety because they are no longer taking threatening mathematics courses may not remember being mathematics anxious. Although it appears on the surface that these students may be successful in the lessening or elimination of mathematics anxiety, they actually may be limiting their career options by avoiding challenging mathematics courses. They may be unaware that their present course and career choices are based on avoiding certain courses and career paths in the past.

1.4 Purpose of the Study

This study will develop an in-depth understanding of the effect of mathematics anxiety upon course and career choice of the high school vocational-technical education student. As a group, the high school vocational-technical education student has had limited study in terms of mathematics anxiety and career choice. Little research has been directed at the career planning and occupational identity of adolescents (Wulff & Steitz, 1997) and mathematics anxiety of secondary students (Ma, 1999).

High school vocational-technical education students tend to be less prepared than college bound students in the number and the level of mathematics courses taken (Dick & Rallis, 1991) and these students tend to enter the labor market earlier than college bound students (Grimes & Scalise, 1987). This study has implications for the understanding of the academic issues concerning high school vocational-technical education students and their career choice.

To assess student mathematics anxiety level, both the 24-item researcher developed Abbreviated Mathematics Anxiety Rating Scale for Adolescents (MARS-A) and the 98-Item MARS-A (Suinn & Edwards, 1982) will be used. To measure the factors in the course and career choice process, the researcher developed

Career Choice Survey will be used. The pilot study will be used to test these data collection instruments to determine areas that may require any modifications. For a discussion of the pilot study, please refer to the pilot study section in the Data Analysis section of Chapter 3 (p. 65). The data collected from these instruments in the study will be followed up with in-depth interviews of selected students to be used as cross validation of the data collected from the quantitative instruments. Both quantitative and qualitative paradigms will be employed to add depth of understanding of the effect of mathematics anxiety on course and career choice.

1.5 Significance of the Study

The results of this investigation will be helpful for students, parents, guidance counselors, teachers, curriculum coordinators and administrators in helping students identify mathematics anxiety's contributing effect in course and career choice. Teachers have a significant impact on the success of the students in their class. Students who view their teachers in a positive light tend to exhibit achievement-oriented behaviors (McCoach & Siegle, 2001). In fact two-thirds of the effect of school on student learning derives from effective teaching (Marzano, 2003). Sanders and Horn, (1994) and Wright, Horn, and Sanders, (1997), found that the teacher is the most important factor affecting student learning and that teachers who do not use effective instructional practices will find their students falling further behind in their learning when compared to students who have been taught with effective instructional practices (Marzano, 2003). It is important that teachers be aware of the effect that mathematics anxiety has on their students so that effective teaching strategies can be employed to increase student learning.

1.6 Research Questions

The following research questions were addressed in this study: (1) Is mathematics anxiety a significant factor in the course and career choice of high school vocational-technical education students?, and (2) Does mathematics anxiety affect course and career choice differently, based on gender?

1.7 Limitations of the Study

The process of choosing participants for the study was through voluntary self-selection. Ninth grade students were purposefully selected due to their proximity to the time when they decided to enter the vocational-technical education program. Most students decide to enter the vocational-technical education program in the 8th grade. Every effort was made to obtain as wide and diverse a sample as possible to ensure that it is representative of the entire school population. While an adequate sample size was not obtained which has limited the generalizability of the study, the data collected from the student interviews provided significant insights.

Chapter 2: Literature Review

Research indicates that many factors influence a student's course and career choice. Some of these are: the family (Auster & Auster, 1981; Ferry et al., 2000; Kotrlik & Harrison, 1987; Otto, 2000; Phillips & Imhoff, 1997), career self-efficacy (Lent et al., 2002), and peers (Auster & Auster, 1981; Kotrlik & Harrison, 1987; Lent et al., 2002). Some factors may have more weight than others may in the career choice process.

Little research has been conducted on the learning styles of vocational education students (Slaats et al., 1999), the career planning and occupational identity of adolescents (Wulff & Steitz, 1997), or on mathematics anxiety of elementary and secondary students (Hembree, 1990; Ma, 1999). This review of the literature will trace the historical development of the study of mathematics anxiety, the theoretical underpinnings of the study – self-efficacy and its influence on course and career choice, the impact of adolescence on the course and career choice of students, the characteristics of high school vocational-technical education students, the limited research in the course and career choice process of adolescents, the effect of mathematics anxiety on high school vocational-technical education students, and parent, peer, teacher, and gender influence on course and career choice.

The concept maps below illustrate the inter-relationship of these influences on the course and career choice of high school vocational-technical education students. The effect of mathematics anxiety on mathematics efficacy is such that as mathematics anxiety increases, mathematics self-efficacy decreases and vice versa. These two constructs are intertwined and inseparable. Each directly influences the other and these two together directly influences course and career choice. In Figure 1, the inter-related affect of mathematics anxiety, mathematics efficacy, parents and teachers influences on the student efficacy in elementary, middle/junior, and high school is presented. All of these influences may effect the student's efficacy beliefs and may influence course and career decisions in middle/junior high school and in high school. If a student experiences mathematics anxiety and low mathematics efficacy in elementary school this may influence the student's course choices in middle/junior high school. Likewise, mathematics anxiety and low mathematics efficacy experienced in middle/junior high school may influence the student's course and career choices in high school.

Figure 2 presents the effect of high mathematics anxiety and low mathematics self-efficacy on the student's course and career choice in high school. High levels of mathematics anxiety and low mathematics self-efficacy can lead the student to avoid mathematics related careers or higher level mathematics courses in high school. This in turn may affect the student's career choice. The student's career interest may be strong enough to counter the adverse effect of mathematics anxiety and low mathematics efficacy on their career choice or the student's career choice may be adversely affected by mathematics anxiety and mathematics efficacy.

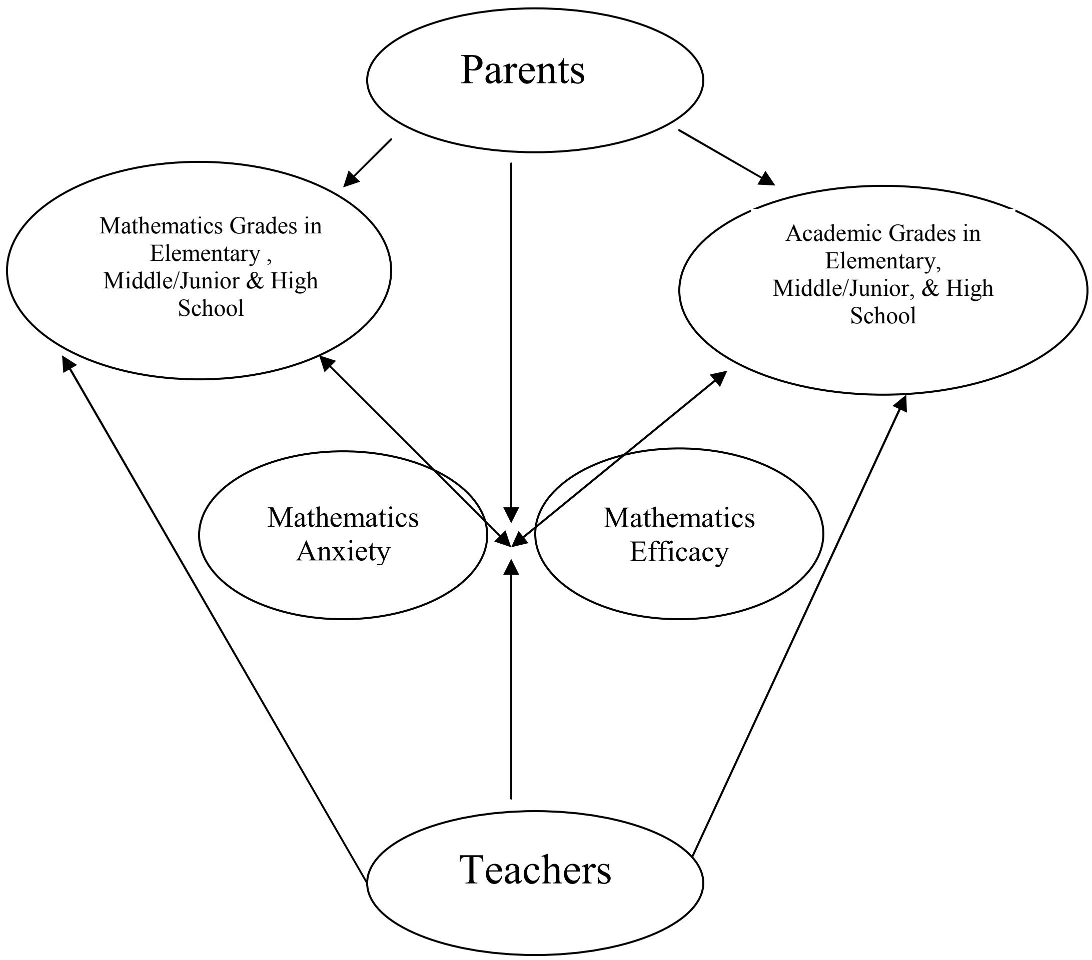

Figure 1. The Inter-related Effect of Mathematics Anxiety, Mathematics Efficacy, and Parents' and Teachers' Influences on Student Efficacy in Elementary, Middle/Junior, and High School

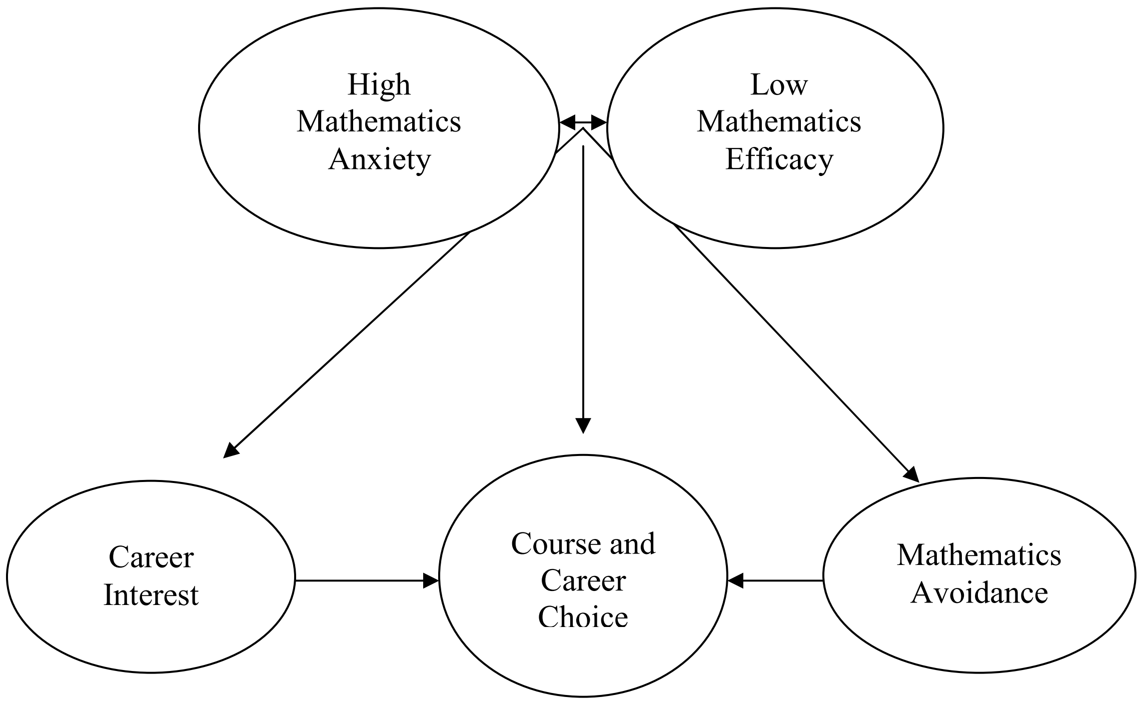

Figure 2. The Effect of High Mathematics Anxiety/Low Mathematics Efficacy on the Student's Course and Career Choice in High School

2.1 Historical Development of the Study of Mathematics Anxiety

Mathematics anxiety has been studied extensively over the last fifty years. Research shows that mathematics anxiety is caused or influenced by past experiences with teachers, the classroom environment, parents (Cemen, 1987; Fitzgerald, 1997) though not inherited from parents (Stuart, 2000) and from remembering poor mathematics performance (Cemen, 1987; Ferry et al., 2000; Tobias, 1985).

"Mathematics anxiety" was first detected in the late 1950s. Dreger and Aiken (1957) noticed undergraduate college students reacting emotionally to arithmetic and mathematics. Although this reaction appeared to be similar to test anxiety in general they found that in mathematics it was a construct all its own and labeled it *number anxiety* (Dreger & Aiken, 1957 p. 344). In fact test anxiety research contains a section that explicitly acknowledges mathematics anxiety (Hembree, 1990). Sarbin (1964) found that the word anxiety derived from the Old French word *anguisse*, which referred to choking sensations in the throat (Friman, Hayes, & Wilson, 1998). Lewis (1970) defined anxiety as a state of emotion supported by fear and dread (Hembree, 1990). It is a physiological reaction to events with uncertain but potentially adversive outcomes (Friman et al., 1998).

In 1972, Richardson and Suinn (1972) defined mathematics anxiety as a feeling of anxiety that interferes with a person's ability to work with numbers and solve mathematical problems both in academic and real life situations (Richardson & Suinn, 1972). In 1980, Richardson and Woolfolk (1980) found that mathematics anxiety was not only an emotional reaction to the use of mathematics but also to the content of mathematics (Richardson & Woolfolk, 1980). Buxton (1981) identified panic, fear, anxiety, and embarrassment resulting from an emotional reaction to doing mathematics (Ma, 1999). In 1987, Cemen (1987) expanded the definition of mathematics anxiety to include a perceived threat to self-esteem (Cemen, 1987). The fear reaction caused by mathematics anxiety can also cause physical effects such as dry mouth, sweaty palms, queasy stomach or a headache (Fotoples, 2000) from activation of the autonomic nervous system (Rothbart & Jones, 1998). Anxiety in the extreme can lead to elevated heart rate, respiration, perspiration, and blood pressure (Friman et al., 1998).

The unpleasant emotion of anxiety is directed towards fear of threats in the future and is out of proportion to the real threat (Hembree, 1990). Mathematics anxious students do not like preparing for, waiting for, or taking mathematics tests. Many become anxious if they think they will be called on in class to do anything mathematical where others will be watching and perhaps evaluating their abilities (Brush, 1981). If they are unable to control this anxiety it can debilitate their performance (Cemen, 1987).

Cemen (1987) found that mathematics anxiety was a process of situational antecedents, which included the stressor and the contextual factors surrounding the stressor. The stressor would lead to mathematics anxiety only if it was a perceived threat to the person's self-esteem. Contextual factors that could contribute to mathematics anxiety include the classroom environment, the way mathematics is taught, the nature of mathematics being learned, and situational antecedents of test anxiety (Cemen, 1987; Kelly & Tomhave, 1985). The student fearing that he or she will not be successful in mathematics will not want to take the chance of failing or appearing as incompetent. This self-doubt seems to be a personality factor that contributes to mathematics anxiety (Cemen, 1987).

According to Cemen (1987) there are three types of antecedents related to anxiety: environmental antecedents, which occurred in the past and have an indirect effect on the immediate anxiety reaction through dispositional antecedents, dispositional antecedents which determine whether or not the individual will perceive the stressor as threatening to self-esteem, and situational antecedents which surround the stressor and contribute to the perception of a threat. The interaction of these antecedents produces the anxiety (Cemen, 1987).

Wigfield and Meece (1988) found that mathematics anxiety is composed of two components, an affective and a cognitive component. While the affective component relates to perceptions of ability and performance, the cognitive component relates to the perceived importance and effort involved in learning and using mathematics (Wigfield & Meece, 1988). Similarly, Cemen (1987) found that mathematics anxiety is associated with two attitudes towards mathematics: perceived usefulness of mathematics to the student's life or career aspirations and that it is a male domain. If students have mathematics anxiety they may convince themselves that mathematics is not useful and therefore the study of it can be avoided (Cemen, 1987).

Generally, the affective domain in the context of mathematics education refers to beliefs, feelings and moods such as anxiety, confidence, frustration, and satisfaction that describe mathematical tasks. The affective domain is generally more difficult to measure and describe than cognition (McLeod, 1992). This is because affect is less precise than cognition according to H. A. Simon (1982). For example fear can have many distinctions that ordinary language cannot express in a dependable way (McLeod, 1992).

Mathematics anxiety does affect many students and is debilitating (Fitzgerald, 1997). The higher the level of mathematics anxiety, the lower the performance level in mathematics (Hembree, 1990). This was found to be true for adults (Quilter & Harper, 1988), college students (Betz, 1978; Frary & Ling, 1983), high school students (Ma, 1999; Saigh & Khouri, 1983), and elementary students (Chiu & Henry, 1990; Ma, 1999; Raymond & Raymond, 1998), thus indicating the developmental pervasiveness of mathematics anxiety. In contrast, a positive attitude toward mathematics and higher mathematics achievement is related to lower mathematics anxiety (Hembree, 1990). As the student becomes more successful in performing mathematics, aversion to mathematics decreases (Lent, Lopez, Brown, & Gore, 1996b).

Because mathematics anxiety is so wide spread, many are not afraid to admit to having it. Many people believe that learning mathematics is not only useless but a painful experience that is courageously endured. Attitudes are different when it comes to reading. People will proudly admit to having mathematics anxiety but would never admit to not being able to read (Battista, 1999; McLeod, 1992).

2.2 Theoretical Background

The theoretical framework for this study is the social cognitive career theory (SCCT) derived from Bandura's (1986) general social cognitive theory (Lent, Hackett, & Brown, 1996a). SCCT applies the general social cognitive theory to career psychology focusing on the role that *self-efficacy* beliefs have in vocational and academic interest, choice, and performance. SCCT attempts to understand the process through which people develop their educational/vocational interests, make career-relevant choices, and achieve their educational and occupational goals (Lent et al., 1994). SCCT emphasizes cognitive-person variables, such as self-efficacy, which enable people to exercise personal agency in their career efforts (Lent et al., 2002).

Career choices according to Gottfredson (1981) are made through the process of circumscription and compromise. Careers are chosen through circumscription using a developmental sequence that rejects careers based on one's self-perceptions of careers that are inappropriate for one's gender, have low status, or are too difficult. Then within the limits of those self-perceptions the person looks for the best match of their interests and abilities and then makes a final decision that is a compromise between their desired career and what is available (Lewis, 2000). These self-perceptions could be determined by self-efficacy.

Bandura (1989) defines efficacy beliefs as 'the product of a complex process of self-persuasion that relies on cognitive processing of diverse sources of efficacy information" (p. 1178). These sources of efficacy information include performance mastery, watching others to see how the person's capabilities measure up, verbal persuasion and other social influences from others that indicate the person's capabilities (Bandura, 1989). According to Bandura (1986), self-efficacy is a person's judgment of their capability to organize and carry out a course of action required to attain a desired type of performance (Pajares & Miller, 1995). From the general social cognitive theory, a person's choice of behavior and how much effort they will expend and for how long they will sustain that effort in spite of obstacles and adverse experiences (demonstrating persistence) is governed by one's perception of self-efficacy (Bandura, 1977). A person will have lower performance (efficacy) expectations if they believe that they are not able to be successful due to personal inadequacies rather than due to the particular situation they find themselves to be in (Bandura, 1977).

Therefore, self-efficacy expectations are independent of performance (Bandura, 1977) and are a better predictor of behavior than is the actual capability of the person because they determine what the person will do with the knowledge and skills they have (Pajares & Miller, 1995). This helps to explain why people with similar skills and knowledge perform differently (Pajares & Miller, 1995). Even though two students may have the same skill level, if one of the students perceives him/herself to be inadequate, that student will not perform as well as the student who perceives him/herself as being capable of attaining the desired performance. When a person seriously underestimates their skills they may set lower goals, experience performance anxiety, give up quickly, and avoid challenges they have the potential to meet (Lent et al., 1996a).

Thus the more efficacious a student is, the wider the range of career options that will be considered appropriate and the better prepared the student will be educationally for those careers (Bandura, 1989). A student with a strong sense of efficacy and perceived value of an outcome may choose a career or course of action even if attainment is uncertain while a student who doubts his or her capabilities will avoid such action (Lent et al., 1994).

A student's self-disbeliefs will self-limit career development more from perceived self-inefficacy than from actual inability. By limiting choice behavior that could develop and widen career interests and competencies, self-disbeliefs will create its own validation of the person's narrow career options (Bandura, 1989; Brown, 1999). Together a student's self-efficacy and outcome beliefs influence his or her interests. These interests then help the student to determine their career choice goals (Ferry et al., 2000; Lent et al., 1994).

The student's learning experiences significantly influences self-efficacy and outcome expectations (Ferry et al., 2000) and ability or aptitude will affect a student's career and academic performance (Lent et al., 1994). A student's performance in mathematics (Brown, 1999; Lent et al., 1996b) will directly affect self-efficacy attitudes and outcome expectancies, grades, and indirectly affects course enrollment intentions (Lent et al., 1993) thus influencing career decisions. The stronger the mathematics self-efficacy expectations a student has, the more likely the student will major in mathematics or science in college (Ferry et al., 2000).

These academic self-perceptions along with motivation and self-regulation according to McCoach & Siegle (2001) appear to be a stronger predictor of academic achievement than does the student's attitude towards school or teachers. They go on to say students who have high self-motivation and self-regulation and have positive academic self-perceptions are more likely to be high achievers than students with lower academic self-perceptions, motivation and self-regulation (McCoach & Siegle, 2001). As the student achieves success in mathematics (high grades) his/her sense of efficacy will begin to rise which in turn will lead to increased interest in a career that includes mathematics (Ferry et al., 2000). Whereas underachievers have more negative attitudes toward school than average and high achievers do and according to Bruns (1992), Dowdall & Colangelo (1982), Ford (1996), Supplee (1990) and Whitmore (1980), often have low self-concept or low self-efficacy (McCoach & Siegle, 2001).

2.2.1 *Self-Concept.* In 1984, Byrne defined a term similar to self-efficacy called self-concept as those attitudes, feelings, and knowledge that one has concerning their skills, abilities, appearance and social acceptability (Sherman & Christian, 1999). Self-concept influences the choice of activities, effort expended, persistence, thought patterns, and emotional reactions of the individual (Lent et al., 1996b). Students with poor attitudes toward mathematics often have a low self-concept, feelings of incompetence, a perpetual lack of success in mathematics, and mathematics anxiety (Sherman & Christian, 1999), whereas a positive self-concept and attitude toward mathematics is associated with lower mathematics anxiety (Fitzgerald, 1997).

2.2.2 Defensive Behavior and Avoidance. Pajares & Miller (1995) found that there are three mathematics related self-efficacy judgments that students make in assessing confidence in their ability: to solve mathematics problems, to succeed in mathematics related courses, and to perform mathematics-related tasks. If the student judges that he or she does not have the confidence to be successful then he or she will avoid potentially threatening situations and activities by adopting defensive behaviors such as avoidance even if they are not anxious at that particular moment (Bandura, 1989).

Bandura (1977) found that a "defensive behavior" is maintained because it is successful in reducing the occurrence of adverse events such as enrollment in mathematics courses. This self-protective behavior is difficult to eliminate even when the threat to the person no longer exists because consistent avoidance prevents a person from learning that the real-life conditions may have changed (Bandura, 1977 p. 209). Thus, the student's defensive behaviors have become so successful in avoiding mathematics courses or in taking less challenging mathematics courses that over time his or her level of mathematics anxiety has been greatly reduced or even eliminated because the threat of taking future mathematics or challenging mathematics courses has been eliminated. Since the student's mathematics anxiety has been reduced the mathematics avoidance behavior is reinforced.

Mathematics avoidance was first isolated by Lucy Sells in 1972 (Tobias, 1981) and is a core constituent of anxiety (Friman et al., 1998). It is possible that students, who had mathematics anxiety in elementary school and were successful in avoiding mathematics courses or challenging mathematics courses they viewed as potentially threatening in middle and high school, may find that they have low levels of mathematics anxiety or may not have mathematics anxiety in high school. These students may have forgotten that they once had mathematics anxiety because the threatening situations, which cause mathematics anxiety, have been eliminated. Therefore, students who were "mathematics anxious" in elementary and or middle/junior high school, and are now in high school could be "mathematics avoidant" even if they are presently not mathematics anxious.

The perceived success a student may have found in lessening or eliminating mathematics anxiety through avoidance may actually make the student unsuccessful in broadening their career options. These students may be limiting their career options by avoiding challenging mathematics courses they view as threatening. The student may not be aware that his or her present course and career choices may be the result of earlier mathematics anxiety even though they currently no longer suffer from mathematics anxiety. They may know that they do not wish to take mathematics courses or pursue mathematics-related careers but they may have long forgotten the uncomfortable feelings of mathematics anxiety.

2.3 Middle School, Mathematics Anxiety, and Course Choice

Mathematics anxiety begins to have an adverse effect on mathematics achievement in the 4^{th} grade (Ma, 1999). This correlation gets stronger in junior high school (Aiken, 1970) where mathematics anxiety steadily increases through junior high school and peaks in grades 9 and 10 before leveling off in upper high school and college (Hembree, 1990). Junior high school years are critical in shaping student attitudes toward mathematics especially grades 4 through 7 with 7^{th} grade being the crucial year (Dutton, 1962, 1968). In fact, it has been found that students' valuing of mathematics decreases more after the transition to junior high school especially with girls having less positive views of their ability in mathematics than boys. Also, it is noteworthy that girls report liking social activities much more than mathematics (Wigfield, Eccles, Mac Iver, Reuman, & Midgley, 1991).

What is happening in middle-level and early high school years that lead to an increased level of mathematics anxiety? Developmental science has found adolescence as a time of risk (Eccles et al., 1993). Difficulty with transitions from elementary school to junior high/middle school and from junior high/middle school to high school has been associated with noticeable changes in academic and emotional functioning (Roeser, Eccles, & Freedman-Doan, 1999). In fact research suggests that most adolescents have negative classroom experiences as a result of the transition to junior high school (Eccles et al., 1993). However, adolescence is not uniformly a time of alienation and distress. Students go in and out of distress and alienation throughout adolescence and some experience low levels or no distress or alienation at all (Roeser et al., 1999).

Adolescents who experience severe adjustment difficulties in high school, such as a history of failing classes have a history of alienation and conflicts from their learning experiences (Carlson, Stroufe, Collins, & Jimerson, 1999). Some researchers indicate that students in 9^{th} grade who had trouble adapting to the school environment also had trouble adapting in 7^{th} grade (Murdock, Anderman, & Hodge, 2000).

Research in recent years has indicated that the transition from elementary to middle-level school has a detrimental effect on achievement and motivation of early adolescents (Anderman, 1998; Eccles (Parsons), 1983; Eccles et al., 1993) where self-esteem reaches its lowest level (Wigfield et al., 1991). For some students, early adolescence starts the beginning of a downward spiral of academic failure. This decline in their grades negatively impacts their self-esteem; which in turn has a negative effect on their motivational orientation toward school (Eccles et al., 1993).

These negative effects not only include decreased self-esteem but also decreased perceptions of competence, lower school grades and lower self-concept of ability in specific school subjects (Watt, 2000). By the beginning of 6th grade, a student's school performance strongly impacts their general self-esteem. For example, young adolescents who have high-rated mathematics ability have the highest self-esteem whereas low mathematics-ability adolescents have significantly lower self-esteem than their average- and high-ability peers do, although, these self-perceptions and levels of self-esteem change over time (Wigfield et al., 1991).

Early adolescence is the time when students make important decisions about life and career. Over time, their middle school experiences affect their beliefs and behaviors (Murdock et al., 2000). Osipow (1983) found that the attitudes and values formed during adolescence are important influences on future career behavior (Koski & Subich, 1985). A negative experience in a particular academic course like mathematics during the critical years of adolescence can prevent an adolescent from making career choices that involve work in that particular domain (Anderman, 1998) such as a career or trade utilizing mathematics. Course choices made by adolescents in late middle school and early high school can have a profound effect on the direction of their careers and their life.

Decisions made during adolescence have important implications on vocational development (Bregman & Killen, 1999) and seem to be in some ways irrevocable (Powlette & Young, 1996). They include decisions concerning which academic courses, training, or career to follow (Powlette & Young, 1996). Poor academic grades may prevent students from pursuing the academic track and may force them to follow the vocational-technical education track. In fact course-level placements in middle school strongly effects high school course placements (Dauber, Alexander, & Entwisle, 1996). Therefore, a student's mathematics-related attitude will strongly affect mathematics course and career choices (Watt, 2000).

2.4 The High School Vocational-Technical Education Student

High school vocational-technical education students have unique career decision-making patterns (Kotrlik & Harrison, 1987). Koski and Subich (1985) emphasized that the content of high school college preparatory curriculum is quite different from that of high school vocational-technical education curriculum. They go on to say that students pursue one or the other curriculum based on different career interests (Koski & Subich, 1985).

Some high school vocational-technical education students enter into either the co-op or Pennsylvania Youth Apprenticeship Program (PYAP). These two programs place secondary students in the workplace for credit and reflect their career aspirations (Chin, Munby, & Hutchinson, 2000). Co-op is designed for seniors who have learned all they can from their career program and work in the field reporting back to the school on a weekly basis. PYAP students work 1, 2 or 3 days a week in their career field but receive all of the academic and career training at the vocational-technical education school. These students can enter PYAP as early as 10^{th} grade.

The co-op student tends to be more interested in courses that emphasize long-term career applicability rather than academic courses (Chin et al., 2000). These students enter co-op education to try out their chosen career, explore a possible career or to simply gain general workplace experience. For many the co-op experience reflects their career aspirations rather than academic enhancement, but some do see the value of the co-op experience as a way of helping them gain admission to post-secondary schools that require relevant experience (Chin et al., 2000).

Lewis (2000) found that some students choose high school vocational-technical education as a consequence of many years of unsuccessful educational experience, which has persuaded them not to aspire to college. Their enrollment in high school vocational-technical education is a result of their prior educational experiences. To high school vocational-technical education students, the learning environment of vocational classes is more comfortable than the typical academic classroom (Lewis, 2000). Because these students do not like academic subjects, or have performed poorly in them, they have developed self-perceptions that they should avoid those occupations that require college degrees (Lewis, 2000).

By 10th grade many students stop taking mathematics, which significantly limits their career choices (Lent et al., 1993). Since high school vocational-technical education students tend to dislike academic subjects such as mathematics, and do not enjoy pursuing academic courses or careers requiring a college degree, they tend to be less prepared in the number and level of mathematics courses taken than the college bound student (Dick & Rallis, 1991).

2.5 Limited Research of High School Vocational-Technical Education Students

A major developmental task of adolescence is career planning and occupational identity but little research has been conducted on this age group (Blustein, 1995; Wulff & Steitz, 1997). There has been limited research on the learning styles of vocational-technical education students (Slaats et al., 1999) and of curriculum and learning in the PYAP and co-op educational setting (Chin et al., 2000). Additionally, measures of the extent of the accuracy students have of vocational knowledge of the blue-collar careers taught in high school vocational-technical educational settings have not been found in the research literature (Walls, 2000).

2.6 The Effect of Mathematics Anxiety on Career Choice

One factor that has not been investigated thoroughly is the effect mathematics anxiety has on the career choice of high school students and particularly that of high school vocational-technical education students. A meta-analysis investigating mathematics anxiety published in 1990 by Hembree, illustrates the imbalance of research on mathematics anxiety that focuses more on college students than on elementary or secondary students (Hembree, 1990). In that meta-analysis, 58 studies were investigations of college students and only seven studies investigated elementary and secondary students (Ma, 1999).

There have been many studies conducted on the learning styles of general or higher education students, whereas vocational-technical education students have not received (Steele & Arth, 1998) nearly as much attention (Slaats et al., 1999). Similarly, little research has been directed at career planning and occupational identity of adolescents (Wulff & Steitz, 1997). Betz (1978) found that mathematics anxiety might be a critical factor in the vocational choice of students. Mathematics is a requirement for a wide range of college majors and occupations. According to Hackett (1985) mathematics anxiety, both directly and indirectly, influences the choice of mathematics-related majors and careers.

Mathematics anxiety may prevent the student not only from passing basic mathematics courses but also from taking advanced mathematics and science courses (Richardson & Suinn, 1972). Students who have a high level of mathematics anxiety have lower levels of mathematics achievement (Clute, 1984) and will be less likely to pursue mathematics courses or careers. Therefore, according to research, the amount of mathematics taken in high school and college determines a student's range of career options (Lent et al., 1993). If the student does not take algebra in high school, access to higher-level mathematics and science courses will be denied and their career options will be limited since algebra is a prerequisite for many other mathematics or science courses (Fleischner & Manheimer, 1997). In a study conducted by Lucy Sells (1972) cited in Tobias (1981), 57% of the incoming male college freshmen at Berkeley had taken four or more years of mathematics in high school compared to only 8% of the incoming women. This meant that 92% of the freshmen women were ineligible for three-fourths of the majors at Berkeley (Tobias, 1981).

According to Chipman, Krantz, & Silver (1992) entering college students who are severely mathematics anxious may enroll in majors that require minimal coursework in mathematics. The higher the level of mathematics anxiety, the more likely is the student to avoid mathematics-related tasks, courses or careers (Betz, 1978; Zettle & Houghton, 1998) thus limiting their career choice. Many middle-level students lack the confidence in their ability to do mathematics (Steele & Arth, 1998) with most students leaving high school feeling apprehensive about doing simple mathematical tasks (Battista, 1999). As Hansen (1984) pointed out, adolescents are continually revising their self-efficacy beliefs and outcome expectations through a continuous re-evaluation of successes and failures until late adolescence or early adulthood (Lent et al., 1996a). Since this process is fluid throughout adolescence until late adolescence or early adulthood, unsuccessful experiences with mathematics during adolescence may cause the student to reconsider their ability to perform well in mathematics and to do well in careers requiring mathematical ability.

2.7 Career Choice Influences

There are many other influences on an adolescent's course and career choice aside from mathematics anxiety. These influences include interests and skills developed in school as well as social and economic factors (Lent et al., 1994). Other influences include: an individual's self-efficacy, self-concept, parental, peer, teacher, and counselor influence, and gender identification. Spokane and Decker (1999) found that these influences make up a unified set of complex underlying traits. Personal inability can prevent a student from pursuing a career choice (Lent et al., 2002). Leading factors for career choice of seniors include interest in the work, working conditions, salary/wages, and personal satisfaction (Kotrlik & Harrison, 1987; Lent et al., 2002). Blake and Sackett (1999) believe that there is some overlap between vocational interests and personality (Larson & Borgen, 2002). Actual or vicarious work experiences have been found to influence career choice (Lent et al., 2002).

Super (1957) found that by the age of 10 children pass through the fantasy stage of career development and begin to develop career preferences determined by interests shaped by their experiences of enjoyable activities. Van der Wilk and Oppenheimer (1987) found that children develop more realistic interests in careers and professions between the ages of 8 and 11. McGee & Stockard (1991) found that by age 10 or 11 children have a well-developed understanding of occupational roles (Vondracek, Silbereisen, Reitzle, & Wiesner, 1999).

Cook et al. (1996) found that young adolescents, even before entering high school, are using their concrete knowledge about jobs and the social contexts in which these jobs are situated to make decisions about careers (Vondracek et al., 1999). At this age students rarely have accurate knowledge or conceptual understandings leading to a mature vocational cognition and an informed entry in the occupational world (Walls, 2000). If students during the early stages of career development find mathematics to be a frightening experience the research suggests that they may prematurely eliminate careers demanding mathematical ability.

2.8 Parental Influence

Parents influence students' career choices more than any one else (Kotrlik & Harrison, 1987; Otto, 2000; Phillips & Imhoff, 1997), with the mother being the most influential of all (Auster & Auster, 1981; Kotrlik & Harrison, 1987; Otto, 2000). Trice, Hughes, Odom, Woods, & McClellan (1995) found that parental occupations influence the career aspirations of elementary-school students (Walls, 2000). Both male and female high school students discuss their occupational career plans with their parents, with females reporting more discussions than males (Otto, 2000).

Adolescents turn to parents as a most valuable resource for courses and high school program enrollments (Catsambis, 2001). Catsambis (2001) found a positive relationship between parental involvement and educational success especially in the elementary school grades. Positive parental encouragement for college in the 8th grade is associated with students registering for mathematics, science, and English courses and enrolling in academic high school programs in 12th grade (Catsambis, 2001).

Similarly, students had a persistent interest in a science or technology career if they perceived their parents had a positive attitude toward science when they were in the 8th grade (Farmer et al., 1995). Farmer, Anderson, and Brock (1991) found that science majors in college when compared with students from other majors, had more parental influence in their career planning than the other students (Farmer et al., 1995). Parental encouragement in mathematics was found to significantly influence student's learning experiences (Dauber et al., 1996; Ferry et al., 2000) and attitude toward mathematics (Aiken, 1970). Students' grades in mathematics were higher when students perceived that their parents were encouraging their effort in mathematics (Ferry et al., 2000). Campbell & Laughlin (1988), Oakes (1985), and Rojewski & Yang (1997) found that a disproportionate number of students from lower socio-economic status families enrolled in vocational classes (Lewis, 2000). Mirowsky and Ross (1998) found that parents who are well educated and well off financially may help their children develop skills and habits that make them more effective at schoolwork (Ross & Broh, 2000).

Interesting findings by Buchanan, Eccles, & Becker (1992), Collins (1990), Hauser, Powers, & Noam (1991), Hill (1988), Montemayor (1986), and Paikoff & Brooks-Gunn (1991) have found that early adolescence is a time of a temporary increase in family conflict (Eccles et al., 1993). Although research shows that parents positively influence their children in both course and career choices, at the pivotal time of early adolescence when adolescents are making important educational and career path decisions, adolescents find themselves alienated from their parents and their grades and interest in school declining. What impact this complex combination of alienation from parents and school has on course and career choice of adolescents has not been investigated in the literature.

2.9 Peer, Teacher, and Counselor Influence

Peers influence adolescent career choice (Auster & Auster, 1981; Kotrlik & Harrison, 1987; Lent et al., 2002) and positively or negatively influence students' attitudes toward mathematics (Stuart, 2000). Recent research by Harris (1995, 1998) indicates that peer influence outweighs parental influence (Falbo, Lein, & Amador, 2001). Vocational teachers influence students' career choice in their respective vocational course if students have been with their teacher for three or more years, and are more influential than counselors in career choice (Kotrlik & Harrison, 1987).

2.10 Gender Identification

Only about one percent of the students of both sexes in any large state university will major in mathematics. In some institutions women may be only 30 percent of that one percent (Tobias, 1981). Research suggests that gender influences mathematics achievement (Anderman, 1998). Girls have a less positive view of their ability in mathematics (Frary & Ling, 1983; Wigfield et al., 1991), and have less educational and vocational choices than boys (Eccles, 1994).

More recently, a 100 study meta-analysis by Hyde, Fennema, and Lamon (1990) has found that the gender gap in mathematics performance has declined over the years (Kianian, 1996). There are no gender differences in mathematics achievement between boys and girls through junior high, but by the end of high school men outperform women (Armstrong, 1981). Efficacy expectations play a significant role in mediating gender differences in the choice of college mathematics majors (Hackett, 1985). Males tend to be more confident than females, even when females perform well in mathematics (McLeod, 1992).

The pursuit of mathematics courses and mathematics related careers might not fit one's culturally defined gender role schema (Eccles, 1994; Kelly & Tomhave, 1985). As a result, females may reject careers that are not deemed by society as fitting their gender role. When compared with males, female adolescents' aspirations and expectations were for more traditionally female occupations (Armstrong & Crombie, 2000). This "mathematics avoidance" among women according to Tobias (1981), is deeply rooted in adolescent and adult women's sex-role socialization and self-image, and often leads to panic and anxiety. Expectations of success in mathematics have a different meaning for men and women. Men view a high level of mathematics efficacy as fulfilling masculine sex-role expectations whereas women do not view a high level of mathematics efficacy as fulfilling feminine sex-role expectations (Singer & Stake, 1986).

This adherence to a defined gender role schema may explain why female high school students tend to take fewer upper level mathematics classes in high school (Fitzgerald, 1997), have a less positive attitude towards mathematics (Watt, 2000), and exhibit more mathematics anxiety than males (Ma, 1999). According to Treiman and Terrell (1975) and Rosen and Aneshensel (1978), the mother's occupation had a positive relationship to their daughter's choice of a nontraditional career

(Auster & Auster, 1981). Tangri (1972) found that a mother's working increases the likelihood that a daughter will have high level career aspirations and will select a male dominated occupation (Auster & Auster, 1981).

2.11 Summary

Adolescence is an important developmental step for students. It is during adolescence that decisions are made concerning which academic course and career path to follow. These decisions have a far-reaching affect on one's life and career. There has been limited research of vocational-technical education students concerning their career choice process and effects of mathematics anxiety on their attitudes towards mathematics. Vocational-technical education students typically do not enjoy academic courses and tend to avoid careers that require academic courses or college. Since vocational-technical education students typically enter the job market earlier than the traditional academic student it is important to understand the career choice decision-making process of these students and the effect mathematics anxiety has on their course and career choice.

Mathematics anxiety begins in the 4th grade and peaks in adolescence. It can be caused by past educational experiences, parental influences and remembering poor past mathematics performance. Adolescence is also the time when students make important decisions that effect their career path and course selection. It is during adolescence when students transitioning from elementary school to middle school and from middle school to high school find that self-efficacy, attitudes, achievement, and grades in academic courses may decline, all of which influences course and career choice.

Other influences on adolescents' course and career choice are: parents, peers, teachers, counselors and gender identification. Of these influences, parents are the most influential. Parents' support of mathematics lowers or helps to eliminate mathematics anxiety and encourages adolescents to pursue mathematics courses and mathematics related careers. While adolescents rely on their parents for support in their course and career decisions, as adolescents, they tend to find themselves alienated from their parents and the educational environment. It is in this context that vocational-technical education students determine their course and career choices.

Chapter 3: Design and Methodology

3.1 Overall Approach and Rationale

The purpose of this research was to study the effect of mathematics anxiety on the course and career choice of high school vocational-technical education students. To investigate this question, a mixed methods design (Creswell, 2002) consisting of quantitative and qualitative paradigms was utilized for an in-depth understanding of this relationship.

This study used two quantitative instruments. The first instrument to be used was the researcher adapted Abbreviated 24-Item MARS-A from the 98-Item MARS-A (Suinn & Edwards, 1982) to assess the level of student mathematics anxiety. The psychometric equivalency of the 24-Item MARS-A to the 98-MARS-A could not be determined due to the low sample size. Therefore the 98-Item MARS-A was used in this study. The second quantitative instrument was the researcher developed Career Choice Survey, which was used to measure the student's level of career and mathematics efficacy and its influence on career choice. In-depth student interviews were used to deepen the understanding of the students' course and career choice process. Please refer to the *Development of the Career Choice Survey* section in Chapter 3 for an explanation of the development of the Career Choice Survey (p. 48) and to the *Development of the Abbreviated MARS-A* section in Chapter 3 for an explanation of the development of the 24-item Abbreviated MARS-A (p. 59).

According to Creswell (1994), a purposeful choice of participants that will best provide answers to the research question is central to qualitative research (Creswell, 1994). Accordingly, in this study, 9th grade students were purposefully selected. Since 9th graders are much closer to the time of their decision to attend the vocational-technical education school than students in the higher grades, it was assumed that this proximity to the time of their decision of course and career choice would make their decision making process relatively easy to recall. Of the self-selected 9th grade students who completed the quantitative instruments, a random selection of 11 of the total number of participants volunteered to be interviewed (Creswell, 1994).

The use of structured interviews in data collection is a quantitative approach whereas an unstructured, open-ended interview is qualitative (Creswell, 1994). In this study, structured questions were asked followed by unstructured interview time given to the selected students to further probe their career choice decision process. The purpose of the student interviews was to unlock hidden mathematics anxiety and or avoidance where possible, leading to a deeper understanding of its effect on course and career choice. Refer to Appendix G: Interview Questions for the interview questions.

3.2 Site and Participant Selection

3.2.1 Site Selection. The location for the study was a vocational-technical education high school from southeastern Pennsylvania. At this school, students came from five rural/suburban school districts. The school has a diverse curriculum, which includes the traditional *half-day about vocational-technical education program*, the Pennsylvania Youth Apprenticeship Program (PYAP), and the co-op program. The *half-day about program* consists of vocational-technical education students taking their academic courses at their sending school for half of the school day and their vocational-technical education courses at the vocational-technical education school the other half of the school day. The vocational-technical education school also includes the PYAP and the co-op programs. Please refer to *The High School Vocational-Technical Education Student* section in Chapter 2 for an explanation of these two programs (p. 30).

There are seven clusters each containing a number of individual programs called labs. The seven clusters are: Construction Trades, Cosmetology, Culinary Arts, Engineering & Manufacturing, Health & Human Services, Power & Transportation, and Visual Communications. The labs in each cluster are as follows. In the Construction Trades Cluster the labs or programs of study are: Construction Carpentry, Environmental Horticulture, Heating Ventilation and Air Conditioning (HVAC), Industrial Electricity. The Cosmetology Cluster only has Cosmetology labs. The labs in the Culinary Arts Cluster are: Food Preparation and Baking, The labs in the Engineering & Manufacturing Cluster are: Computer Information Science, Drafting & Design, Precision Machining, Robotics & Engineering, and Welding & Fabrication. The Health & Human Services Cluster labs are: Allied Health, Biotechnology, Health Occupations, and Protective Services. The Power & Transportation Cluster labs are: Auto & Truck Collision Repair, Automotive, Diesel & Heavy Equipment, Outdoor Power Equipment, and Parts & Service Management. The Visual Communications Cluster labs are: Commercial Art and Graphic Arts.

3.2.2 Sampling Method. The population of the school at the time of the study was approximately 1,300 students. The 9th grade population for school year 2003-2004 consisted of 298 students. The participants for the study were 9th grade vocational-technical education students. Ninth grade students were chosen for the following reasons: It is during the 8th grade year that many students decide to enter the vocational-technical education program as an alternative to the academic program. Since incoming 9th grade students are closer than upperclassmen to the time when they made this decision, it was presumed that the decision-making process they used would be fresh in their mind. Secondly, since the researcher did not teach 9th grade, the participants remained anonymous to the researcher throughout the study, which eliminated any researcher bias.

The process of choosing participants for the study was through voluntary self-selection. The students who agreed to participate completed the Career Choice Survey, the 24-Item MARS-A, and the 98-Item MARS-A and were asked to volunteer to be interviewed. The eleven participants who were interviewed from the volunteer group were chosen using the random sampling method.

The adequate sample size for the quantitative portion of the study was determined by using the table based on the work of Krejcie and Morgan (1970). Based on the 9th grade population of 298, the adequate sample size for the quantitative instruments from Krejcie and Morgan's table would be 169 participants. Krejcie and Morgan's table was based on the formula for determining sample size published by the research division of the National Education Association (Krejcie & Morgan, 1970). The authors created this table for ease of use and to facilitate research. The formula used to determine the sample size was as follows:

$s = X^2 NP(1-P) \div d^2(N-1) + X^2P(1-P)$.

s = the required sample size.

X^2 = the table value of chi-square for 1 degree of freedom at the confidence level of 3.841.

N = the population size.

P = population proportion assumed to be .50 which provides the maximum sample size.

d = the degree of accuracy expressed as a proportion. In this case .05 was used (.05) (Krejcie & Morgan, 1970).

The assumptions made in this table are best suited to the purpose of the study. Having the population proportion set to .50 will ensure a significant sample size. Every effort was made to obtain as wide and diverse a sample as possible to ensure that it is representative of the entire 9th grade population. However, due to difficulties encountered in recruitment, the required number as stated in this table was not met. Refer to the *Recruitment of Subjects* section (p. 47) in this chapter for a detailed explanation of the limited number of participants. A limitation of this study was the size of the sample in relation to the population size of 9th grade students attending the vocational-technical education school.

3.2.3 *Recruitment of Subjects.* Prior to recruiting the subjects for the study, the researcher met with each of the 29 lab (vocational class) teachers to explain the purpose of the study, the amount of teacher and student involvement, the impact on curriculum delivery, and the benefit to the student, teacher, the school and parents. Once the teachers were made aware of the study and their responsibility, the researcher met with each cluster to further explain the study and elicit feedback from the teachers for ideas and comments concerning the execution of the study. A faculty meeting and an in-service training session were conducted to instruct the teachers of their responsibilities in the study. The teachers were instructed to encourage student participation, answer student and parental concerns, and collect the signed permission forms. The goal of the in-service meeting was to prepare the teachers for the questions that might be brought to them by their students so as to ensure that an adequate number of participants would be obtained.

The Director of the vocational-technical education school sent a cover letter (See letter in Appendix H: Letter to Parents) explaining the study and the two permission (Consent and Assent) forms to the parents or guardians of each of the 298 ninth grade students in the school. At the same time that the letters were in the mail, the researcher conducted meetings with all 298 of the 9th grade students attending the vocational-technical education school in each of the 29 labs and explained the study in detail. In these class meetings, each 9th grader was handed copies of the cover letter from the Director of the vocational-technical education school and the Consent and Assent forms that were mailed to their homes. The purpose of the meeting with the 9th graders was to have the study and permission forms clearly and fully explained to the students so that they in turn could fully explain the study and forms to their parents or guardians. It was thought that if the students fully understood the nature of the research and the purpose of the forms they could in turn explain this to their parents or guardians and provide answers to any questions that may arise. The 9th graders were also informed that no personal information about them was going to be asked, that they were not to put their name on the questionnaires, and that each 9th grader was anonymous to the researcher. The length of time to complete the questionnaires and to be interviewed was also explained to the students.

A total of 27 students were retained as subjects for this study. The small sample available to the researcher resulted in re-conceptualized changes to the data analysis and what could be drawn as findings. To improve the process of recruitment the standard Consent and Assent forms traditionally used in the field of Education should be used in place of the forms required by the university. This will ensure that the appropriate number of participants will be obtained.

3.3 Development of the Career Choice Survey

The Career Choice Survey was developed to determine the decision-making process that high school vocational-technical education students use to enroll in a specific vocational-technical education curriculum (lab) through both determining the level of mathematics and career self-efficacy and influences that may have an effect of their course and career choice. Mathematics efficacy is the student's belief in his or her ability to be successful in pursuing mathematics courses or activities. The more efficacious the student is concerning mathematics the more likely the student is to pursue mathematics courses or careers that require higher mathematics ability (Clute, 1984; Lent et al., 1996b; Watt, 2000). It has been established by Fennema (1980) that there is an undeniable relationship between mathematics anxiety and mathematics-related performance and career choice (Hackett, 1985). The link exists between mathematics anxiety and mathematics efficacy and career choice. Likewise, career efficacy is the belief in one's ability to be successful in a particular career. The higher one's career efficacy the more likely the person will feel capable of pursuing the career of their choice.

The higher the score on the Career Choice Survey, the higher the level of mathematics and career self-efficacy which may indicate that the student has enrolled in a particular vocational-technical education lab curriculum because it will help the student reach his or her career goals. The Career Choice Survey measures the student's level of career and mathematics efficacy using a Likert scale of 1 to 5. The statements are scored 1 to 5 points each with the score of 5 indicating that this choice exhibits high mathematics or career efficacy. The Career Choice Survey was created using the format of Likert-scale surveys where the higher the score on the survey the higher the level of the positive attitude being measured (Wiersma, 2000), in this case mathematics and career efficacy. Therefore, the higher the student's score on the Career Choice Survey, the higher the student's mathematics and career self-efficacy. Positive statements reflecting high efficacy are scored 5 for *Very Strongly Agree* to 1 for *Very Strongly Disagree*. Negative statements are scored in reverse. It is presumed that if a student has low career self-efficacy, as determined by a low score on the Career Choice Survey, then that student may not have a strongly defined career goal or may not be enrolled in the vocational-technical education lab that the student would like to be enrolled in.

The development of the Career Choice Survey was based on preliminary data collected from 24 students who took the Career Choice Survey, the 98-Item MARS-A, and the Abbreviated MARS-A during the 2001-2002, school year. The Career Choice Survey was reviewed by professionals in the field of education and by the students who took the survey. The original Career Choice Survey contained 44 items. As a result of the preliminary data collected and analysis of the comments from the reviewers and the student participants, the survey used in this study was revised and contained 41 items. Using the criteria for development of effective attitude statements established in Edwards (1983), statements were eliminated or changed if they were ambiguous, used language that was not clear, simple, or direct, or used words not understandable by the population answering the survey.

3.3.1 Content validation. Content validation is the process of establishing how representative the statements on the data collection instrument are of the domain of attitudes being measured (Wiersma, 2000). The content validation for each of the statements on the Career Choice Survey were drawn from the research as shown in Appendix C: Test Specification for Career Choice Survey Drawn from the Following Sources. The statements were further validated by the review of each statement by professional educators (Refer to Appendix D: The Reviewers' Comments of the Career Choice Survey). The reviewers determined that the statements on the Career Choice Survey did measure the domain of attitudes that the Career Choice Survey was designed to measure (Edwards, 1983).

3.3.2.Criteria for Review. The researcher determined review criteria that was presented to the professionals for review of the Career Choice Survey for content validity was as follows: each reviewer was asked to review the statements in the survey for their appropriateness for measuring the process of career choice of high school vocational-technical education students. The reviewers were asked to: indicate statements that did not belong, change the wording of statements to better elicit appropriate information, and add statements that would better obtain the desired information. The reviewers were also asked to review the statements that were grouped in the efficacy categories shown in Table 1, as to their appropriate inclusion in the category. These comments were used to make changes in the Career Choice Survey, where appropriate.

Table 1: Efficacy Categories of the 44-Item Career Choice Survey

Category	Statement Number
Career Efficacy	1, 6, 10, 12, 13, 16, 19, 20, 24, 28, 32, 38, 43, 44
Career Efficacy and Counselor Influence	27, 29, 39
Career Efficacy and Parent Influence	2, 23, 30, 36
Career Efficacy and Peer Influence	22, 42
Career Efficacy and Teacher Influence	37, 41
Mathematics Efficacy	3, 5, 7-9, 11, 14-15, 17, 21, 25-26, 31, 33-35, 40
Mathematics Efficacy and Parent Influence	4

3.3.3 Student Comments on the Career Choice Survey. Each of the 24 students who took the Career Choice Survey also completed the Comments on the Career Choice Survey instrument to assist in the development of a clear, readable, and understandable survey. Please refer to Appendix E: Comments on the Career

Choice Survey to view the student Comments on the Career Choice Survey instrument. This survey asked students to rate their impressions of the Career Choice Survey based on six statements with a 5-point Likert rating scale of Very Strongly Agree, Agree, Undecided, Disagree, and Very Strongly Disagree. The survey point value ranged from 6 to 30 points with the higher the score the more favorably the students thought of the survey. The results of students' answers to the six statements of the Comments on the Career Choice Survey can be found in Table 2. The students were asked in the Comments on the Career Choice Survey to write in additional comments. In Table 3, the written comments from the students are presented.

Table 2: Student Responses to the Comments on the Career Choice Survey

Statement	Yes	No
The survey was too long.		83%
The statements were clearly written.	96%	
The survey touched on all the influences that formed my career choice.	65%	
The survey touched on all my thoughts and feelings concerning math.	78%	
Too many statements were repeated.	61%	17%
I did not get the point of the survey.		78%

3.3.4 Reviewers Conclusion. The reviewers agreed that the Career Choice Survey was effective in measuring the influences in the career choice of students. The students agreed that the survey was clear, readable, and understandable. After reviewing the comments from both the students and reviewers, suggested changes in the Career Choice Survey were made.

Table 3: Student Written Comments

Student	Written Comment
1	"The survey was very precise and complete."
2	"nothing missing"
3	"Too many repeated questions."
4	"Could also be a little shorter, many repeated questions."
5	"It was good. I was able to not drift while doing it, due to it was not too long."
6	"Something that might help is to give a little example after each question, just a thought. But was a good survey."
7	"Noticed a lot of questions were repeated or re-worded."
8	"I like this survey because it's short and they get to the point."

3.3.5 Criterion and Concurrent Validation. By the use of criterion validation, the validity of the items on the Career Choice Survey can be determined through a comparison with a criterion instrument that is external to the survey, such as the 98-Item MARS-A (Wiersma, 2000). As can be seen in Table 4, the mathematics efficacy portion of the Career Choice Survey is significantly negatively correlated with the 98-Item MARS-A at -.635 (2-tailed) at the .001 significance level. Research has established that high mathematics anxiety indicates low mathematics efficacy (Cemen, 1987; Clute, 1984; Steele & Arth, 1998). This indicates that as the student's level of mathematics anxiety goes up his or her score on the mathematics efficacy portion of the Career Choice Survey will go down. A low score on the mathematics efficacy component of the Career Choice Survey and a high score on the MARS-A would indicate that the mathematics efficacy component does measure mathematics efficacy. Therefore, by concurrent validation (data on the two survey instruments were gathered at the same time) of the data collected from the MARS-A and the mathematics efficacy component of the Career Choice Survey, the negative correlation between these two instruments indicated that the Career Choice Survey was measuring mathematics efficacy as it was intended to measure.

Table 4: Correlations Math Efficacy of Career Choice Survey to 98-Item MARS-A & 24-Item MARS-A

Correlations

		Math Efficacy	98-MARS-A	24-MARS-A
Math Efficacy	Pearson Correlation	1.000	-.635**	-.313
	Sig. (2-tailed)	.	.001	.136
	N	24	24	24
98-MARS-A	Pearson Correlation	-.635**	1.000	.774**
	Sig. (2-tailed)	.001	.	.000
	N	24	24	24
24-MARS -A	Pearson Correlation	-.313	.774**	1.000
	Sig. (2-tailed)	.136	.000	.
	N	24	24	24

** Correlation is significant at the 0.01 level (2-tailed).

A low score on the Career Choice Survey and a high score on the mathematics anxiety scales may indicate mathematics anxiety may be preventing the student from enrolling in the vocational-technical education curriculum (lab) they would otherwise want to be enrolled in. If the student views mathematics negatively, it is presumed that the student may not enroll in lab curriculums that are mathematics oriented or that require higher levels of mathematics ability even though the student may want to be enrolled in those labs or pursue those careers. The student may choose labs with lower mathematics requirements. If the student views mathematics positively, the student may not be afraid to enter labs that are mathematics oriented or that require higher mathematics ability. Referring to Table 5, the Career Choice Survey is significantly negatively correlated with the 98-Item MARS-A at -.449 (2-tailed) at the .05 significance level. This indicates that as the Career Choice Survey score goes down, the mathematics anxiety score will tend to go up indicating that the student may have mathematics anxiety, which may be interfering with the student's career choice.

Table 5: Correlations Between the MARS-A and the Career Choice Survey

Correlations

		98-MARS-A	Career Choice Survey
98-MARS-A	Pearson Correlation	1.000	-.449
	Sig. (2-tailed)	.	.028
	N	65	24
Career Choice Survey	Pearson Correlation	-.449	1.000
	Sig. (2-tailed)	.028	.
	N	24	24

* Correlation is significant at the 0.05 level (2-tailed).

3.3.6 Reliability of the Career Choice Survey. The Career Choice Survey's reliability analysis revealed a significant alpha coefficient of .8568. The split reliability alpha for part 1 and part 2 are both significant at .7960 and .7151 respectively. See Table 6 for the reliability analysis.

Table 6: Reliability of the Career Choice Survey

R e l i a b i l i t y a n a l y s i s - s c a l e (a l p h a)	
Reliability Coefficients	
N of Cases = 24.0	N of Items = 44
Alpha = .8568	
R E L I A B I L I T Y A N A L Y S I S - S C A L E (S P L I T)	
Reliability Coefficients	
N of Cases = 24.0	N of Items = 44
Correlation between forms =.6959	Equal-length Spearman-Brown = .8207
Guttman Split-half = .8188	Unequal-length Spearman-Brown =.8207
22 Items in part 1	22 Items in part 2
Alpha for part 1 = .7960	Alpha for part 2 = .7151

3.4 Development of the Abbreviated 24-Item MARS-A

3.4.1 Background of the MARS-A. In 1972 the Mathematics Anxiety Rating Scale (MARS) (Richardson & Suinn, 1972; Suinn, Edie, Nicoletti, & Spinelli, 1972) was developed for use in research to measure anxiety "associated with the single area of the manipulation of numbers and the use of mathematical concepts" (Richardson & Suinn, 1972 p. 551). This scale, composed of 98 items, describing situations involving mathematics in ordinary life and academic settings, was developed for use with college students and adults.

In 1982, Suinn and Edwards revised the MARS for use with adolescents by changing the wording of items that would be more appropriate to adolescents (Suinn & Edwards, 1982). The revised 98-item MARS-A (Adolescent) listed situations that adolescents might experience while dealing with numbers. Suinn and Edwards (1982) believed that attitudes toward mathematics performance are formed early in the student's educational experience and that these attitudes affect career choices made by junior and senior high school students (Suinn & Edwards, 1982). They believe the MARS-A will be of value in identifying those adolescents who experience mathematics anxiety so that they can receive the support they need to overcome it.

3.4.2 Researcher Experience with the MARS-A. When the 98-Item MARS-A was administered to vocational-technical education students by the researcher in previous years, students appeared to have difficulty completing the scale. The length of the questionnaire appeared too long for the students to maintain the concentration needed to fully and accurately complete the MARS-A. This spurred the search for a shorter version of the MARS-A.

3.4.3 Communications with Dr. Suinn, Creator of the MARS-A. The researcher contacted Dr. Suinn in May 2002 to inquire if a shorter version of the 98-Item MARS-A existed. Dr. Suinn informed the researcher that he had been working on a shorter version but that after considerable thought felt a shorter version was not necessary. Later in June of 2002 the researcher contacted Dr. Suinn concerning the development of the Abbreviated 24-Item MARS-A. The researcher's rationale was presented to Dr. Suinn as discussed below (R. M. Suinn, personal communication, June 1, 2002). Dr Suinn expressed interest in the results obtained from this study.

3.4.4 Development of the 24-Item MARS-A. When a shorter version of the MARS-A was not found, the researcher began to investigate shorter versions of the adult version of the MARS. If a shorter version of the adult MARS could be found, perhaps it could be used as a guide for creating a shorter version of the MARS-A. Two shorter versions of the MARS were found, one from Alexander & Martray (1989) and one from Plake and Parker (1982). None were found for the MARS-A.

Alexander & Martray (1989) took the 98-item MARS for college students and adults and created a psychometrically equivalent 25-item version (Alexander & Martray, 1989). Alexander and Martray (1989) were not the first to revise the MARS. Plake and Parker (1982) created a 24-item abbreviated MARS with an internal consistency coefficient (alpha) of .98, and a .97 correlation with the full 98-item MARS. Plake and Parker's (1982) abbreviated scale targeted upper level undergraduates and graduate statistics students using the definition of mathematics anxiety as being apprehension about taking mathematics courses and doing mathematics problems (Plake & Parker, 1982).

Both Alexander & Martray (1989) and Plake & Parker (1982) determined that their 25-item and 24-item abbreviated MARS instruments respectively were psychometrically equivalent to the 98-item MARS by Richardson and Suinn (1972). These two versions were for use with undergraduate students. The Plake & Parker (1982) version however was for upper level undergraduates and graduate students while the Alexander & Martray (1989) version was for undergraduates in general. Since these two instruments were effective in abbreviating the MARS, the researcher wished to investigate whether the same could be done with the adolescent version of the MARS, the MARS-A, developed by Suinn & Edwards (1982).

Because the Alexander & Martray (1989) version was developed for the general undergraduate and therefore closer to the age group I was interested in studying, than the 24-item Plake & Parker (1982) version, I decided to use Alexander & Martray's (1989) 25-item instrument as a guide to develop a psychometrically equivalent Abbreviated MARS-A. To accomplish this, the first step was to map each item in the 25-item MARS (Alexander & Martray, 1989) to the equivalent item in the 98-item MARS-A (Suinn & Edwards, 1982).

Since the abbreviated 25-Item MARS (Alexander & Martray, 1989) was determined to be psychometrically equivalent to the 98-item MARS (Suinn et al., 1972) then the same 25 items mapped to the 98-Item MARS-A (Suinn & Edwards, 1982) might be psychometrically equivalent to the 98-item MARS-A

(Suinn & Edwards, 1982). See Figure 3.

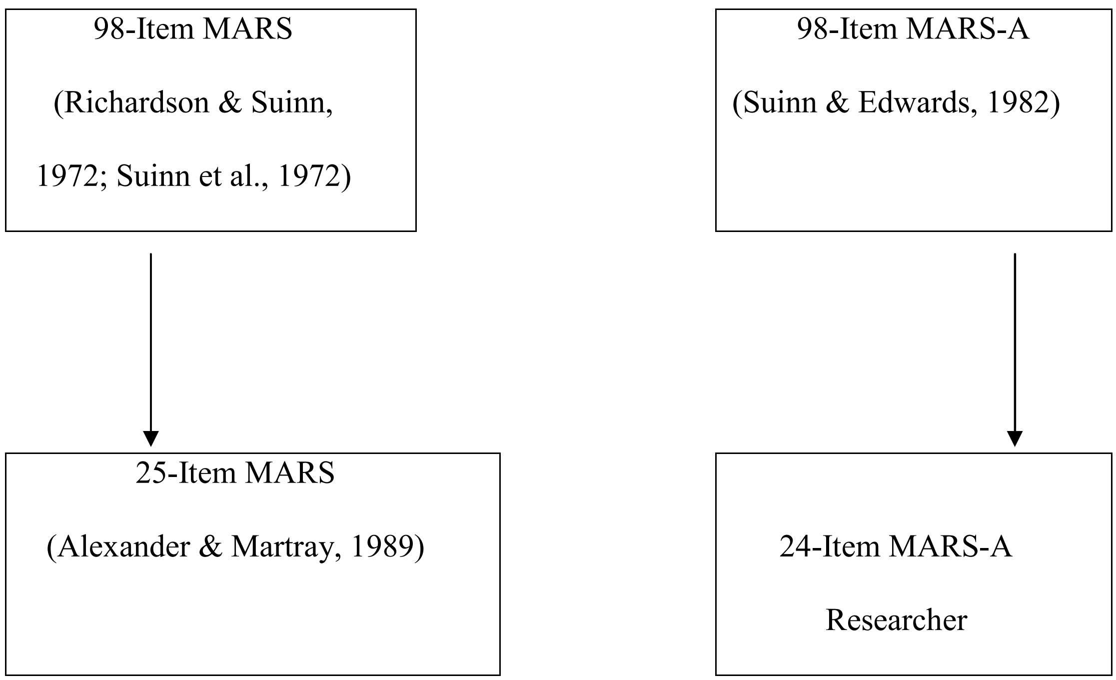

Figure 3. Mapping 98-MARS-A to 24-Item MARS-A

I matched each one of the 25 items from Alexander and Martray's (1989) version of the MARS to the equivalently worded statements found in the MARS-A (refer to Appendix C: Test Specification for Career Choice Survey Drawn from the Following

Sources). The following 22 item numbers in the MARS-A appear word for word as items in the 25-item abbreviated MARS by Alexander and Martray (1989) 24*, 26, 27*, 28*, 34, 47, 53*, 54*, 67, 68, 69, 70, 71*, 72*, 73, 74*, 75, 81, 82, 85, 88, and 91*. The items with the "*" are items (10) that also appear on Plake and Parker (1982) 24-item abbreviated MARS.

There were two items that appeared on the 25-item MARS that were rewritten for the MARS-A. The first of these is item number 43 on the MARS-A, "Taking the math section of a standardized test, like an achievement test" was rewritten from the MARS item number 22, "Taking the math section of college entrance exam". The second item is number 23* on the MARS-A, "Receiving a math textbook", rewritten from the MARS item number 6, "Buying a math textbook". The slight rewording of these two items was appropriate for their respective populations while still retaining the essence of each item. There was one statement on the MARS that did not appear on the MARS-A. The MARS statement number 64 "Getting ready to study for a math test" did not have an equivalent match on the MARS-A and was not included in the Abbreviated MARS-A the researcher was developing.

Therefore it can be reasoned that the use of the new researcher developed 24-item Abbreviated MARS-A would have the benefit of quicker administration and scoring while being psychometrically equivalent to the 98-Item MARS-A.

3.5 Data Collection Methods

The student's technical lab teacher collected the permission forms to maintain the confidentiality of the students and notified the researcher as to the total number of students from their lab who wished to participate in the study. A total of 27 students wished to participate in the research study. The researcher did not teach 9th grade and therefore none of the participants in the study were students of the researcher. The researcher met with each lab teacher prior to data collection to explain the purpose of the study and how it would be carried out. Suggestions from the teachers were elicited to ensure easy delivery of the instruments with the least disruption of class time. The Career Choice Survey, the 24-Item MARS-A, and the 98-Item MARS-A were completed in 10-30 minutes. The student in-depth interviews were conducted one-on-one in sessions lasting less than an hour where students reflected on their course and career choice decision-making process.

3.5.1 Quantitative Instruments. Three quantitative data collection instruments, the Abbreviated 24-Item Mathematics Anxiety Rating Scale for Adolescents (MARS-A) (Refer to Appendix A: Abbreviated Mathematics Anxiety Rating Scale (MARS-A)), the 98-Item MARS-A, and the Career Choice Survey (Refer to Appendix B: Career Choice Survey) were used in this study. The 24-Item Abbreviated MARS-A and the 98-Item MARS-A measured the student's level of mathematics anxiety. The researcher developed Career Choice Survey provided demographic information and academic history along with a Likert scale on which the students' responses indicated their career choice decision process. The use of the researcher adapted 24-item Abbreviated MARS-A and the 98-Item MARS-A gave a baseline level of student mathematics anxiety and was used in comparison with data collected from the Career Choice Survey to determine the relationship between mathematics anxiety and career choice. The Career Choice Survey, the 24-Item MARS-A, and the 98-Item MARS-A were given to the students by the researcher, in the students' lab. The students were unidentified to the researcher.

3.5.2 Interview protocol. From analysis of the data collected from the Career Choice Survey, the 24-Item MARS-A, and the 98-Item MARS-A, structured questions were developed reflecting the responses of the students. Through both structured questions and open-ended student directed responses, the student's career choice decision process was uncovered. The use of open-ended questions allowed the interviewer the opportunity to pursue topics and directions initiated by the interviewee. The interview questions found in Appendix G: Interview Questions were the starting point. Through the interview process mathematics avoidance and anxiety factors influencing the career choice decision process were uncovered.

3.6 Data Analysis

3.6.1 Pilot Study. The pilot study was to be used to determine the psychometric equivalency of the researcher adapted 24-Item Abbreviated MARS-A with the 98-Item MARS-A (Suinn & Edwards, 1982). This was not done due to the small N. The sample size needed for the pilot study should be between 35 and 100. Factor analysis was to be used to determine if the 24-item Abbreviated MARS-A tested the same factors that the 98-item MARS-A tested (Suinn & Edwards, 1982), and if there were primary factors that could be used to account for the variance in the test items in each version of the MARS-A (Kachigan, 1991). This could not be done due to the small N. The confidence interval for the sample size obtained was 18.02 as opposed to the 4.97 confidence interval if the sample size had been the required 169. With the confidence interval being as large as it was, the level of possible error was too great to determine the psychometric equivalency of the two scales.

Data analysis made use of the Pearson Correlation between the level of mathematics anxiety and the mathematics and career efficacy levels measured by the mathematics anxiety scales and the Career Choice Survey. Having a low career self-efficacy and a high level of mathematics anxiety could indicate that the student did not choose the lab curriculum desired due to perceived inability to perform the required mathematics of that curriculum.

The data collected from the Career Choice Survey, the 98-Item MARS-A, and the 24-Item MARS-A during the study was followed up with in-depth interviews of 11 randomly selected students who completed the data collection instruments listed above. Methods used by Greene & Stitt-Gohdes (1997), in which the interviews were tape recorded and transcribed for research purposes (Greene & Stitt-Gohdes, 1997) were employed by the researcher. After the data collected from the quantitative instruments were analyzed and the interview questions determined as a result of this analysis, the students were interviewed individually by the researcher. Each interview was less than one hour in length.

Both quantitative and qualitative methods of data collection and analysis were employed to add depth of understanding of the effect of mathematics anxiety on student course and career choice. Student interview responses were categorized and coded to observe the emerging patterns in the responses. The data from the quantitative instruments were used to cross validate the data collected from the interviews.

Chapter 4: Results

The purpose of this study was to determine (a) the effect of mathematics anxiety on the course and career choice of high school vocational-technical education students and (b) whether mathematics anxiety affects course and career choice differently based on gender. As demonstrated in Chapter 2, mathematics anxiety and mathematics efficacy are inversely related. As mathematics anxiety increases, mathematics efficacy decreases and vise versa. When a student's mathematics efficacy decreases the student may begin to feel incapable of performing well in mathematics related activities, courses or careers, and in turn, this may affect the student's course and career choice.

Through the triangulation of the following three independent data collection sources: student interviews, the 98-Item MARS-A (measuring mathematics anxiety), and the Career Choice Survey (measuring career and mathematics efficacy), an understanding was gained of the effect of mathematics anxiety on the course and career choice of 9th grade vocational-technical education students.

The total population of 9th graders from the school being studied was 298. The sample size obtained for the study was 27 students, which did not meet the number necessary for generalizability (see explanation on page 47 in Chapter 3). Due to the small sample size acquired for the study the data collected from the Career Choice Survey and the 98-Item MARS-A may not reflect the characteristics of the population as a whole. The number of students interviewed exceeded the required sample size for the qualitative portion of the study. Due to the small sample size the determination of the psychometric equivalency of the researcher developed 24-Item MARS-A with the 98-Item MARS-A could not be conducted.

The sample size acquired for this study was 27 students of these 11 students were interviewed. All were given the Career Choice Survey and the 98-Item MARS-A to determine each student's level of mathematics anxiety and mathematics and career efficacy. The results from these instruments were analyzed and patterns discovered. These results were then used to formulate the interview questions. Once this was accomplished, 11 of the students from the sample were then interviewed. The results of the interviews were analyzed to give meaning to the patterns discovered from the Career Choice Survey and the 98-Item MARS-A.

4.1 Student Demographics

The participants in this study were vocational-technical education students drawn from five rural suburban school districts in southeastern Pennsylvania. Seventy-four percent (20) were male and 26% (7) were female. From these participants, 11 students, eight male and three female were interviewed. The ages ranged from 14 through 17 with a mean age of 15. One-third of the students had an

Individual Education Plan (IEP) with more than half of the students deciding to enroll in the vocational-technical education school in the 8th grade and 41% enrolling in the 9th grade.

4.2 Career Choice Survey

The 41 items on the Career Choice Survey were divided into two groups. Twenty-one of the items were used to determine the career efficacy of the student. Twenty items were used to determine the mathematics efficacy of the student. The alpha coefficient for the Career Choice Survey was .8499 (.8802 for the interviewed students). Refer to Table 7.

The Career Choice Survey was correlated to the 98-Item MARS-A to determine the relationship between mathematics and career efficacy with mathematics anxiety levels. Directionality was anticipated based on previous data from classroom research. There was a mildly negative correlation between the Career Choice Survey and the 98-Item MARS-A of -.263 $p < .092$ (1-tailed).

The mathematics efficacy component of the Career Choice Survey was significantly negatively correlated to the 98-Item MARS-A at -.421, $p < .05$ (1-tailed). Refer to Table 8. As the student's score on the mathematics efficacy portion of the Career Choice Survey went up, their level of mathematics anxiety went down as measured by a low score on the 98-Item MARS-A. This demonstrated the inverse relationship between mathematics efficacy and mathematics anxiety. As the student becomes more mathematics efficacious, their level of mathematics anxiety will tend to decrease.

Table 7: Reliability of the Career Choice Survey for All Students in the Study

RELIABILITY ANALYSIS - SCALE (ALPHA)	
Reliability Coefficients	
N of Cases = 27.0	N of Items = 41
Alpha = .8499	
RELIABILITY ANALYSIS - SCALE (SPLIT)	
Reliability Coefficients	
N of Cases = 27.0	N of Items = 41
Correlation between forms = .7305	Equal-length Spearman-Brown = .8443
Guttman Split-half = .8442	Unequal-length Spearman-Brown = .8443
21 Items in part 1	20 Items in part 2
Alpha for part 1 = .7129	Alpha for part 2 = .7675

Table 8: Pearson Correlation of Career Choice Survey, 98-Item MARS-A, Mathematics Efficacy and Career Efficacy Components of the Career Choice Survey

Correlations

		Math Efficacy	Career Efficacy	CCS	98-Item MARS-A
Math Efficacy	Pearson Correlation	1.000	.385*	.891**	-.421*
	Sig. (1-tailed)	.	.024	.000	.014
	N	27	27	27	27
Career Efficacy	Pearson Correlation	.385*	1.000	.762*	.065
	Sig. (1-tailed)	.024	.	.000	.374
	N	27	27	27	27
CCS	Pearson Correlation	.891**	.762**	1.000	-.263
	Sig. (1-tailed)	.000	.000	.	.092
	N	27	27	27	27
98-Item MARS-A	Pearson Correlation	-.421*	.065	-.263	1.000
	Sig. (1-tailed)	.014	.374	.092	.
	N	27	27	27	27

* Correlation is significant at the 0.05 level (1-tailed).

** Correlation is significant at the 0.01 level (1-tailed).

4.3 The 98-Item MARS-A

The mean score on the 98-Item MARS-A for the interviewed students was 233.18, which was much higher than the mean score for the entire sample of 216.15. Based on 9th grade normative data from the 98-Item MARS-A (Suinn & Edwards, 1982) a score of 201 (60th percentile) or above indicates moderate mathematics anxiety. A score of 229 (75th percentile) indicates high mathematics anxiety. This puts the mean score (233.18) of the interviewed students well above the 75th percentile indicating high levels of mathematics anxiety. The mean score for the entire sample falls between the moderate and the high range of mathematics anxiety. The 50th, 60th and 75th percentile for the data collected in this study from the Career Choice Survey and the 98-Item MARS-A were determined and analyzed. Refer to Table 9 for the entire sample and Table 10 for the interviewed students.

Table 9: Percentiles for Career Choice Survey, and 98-Item MARS-A for All Students

Statistics

		CCS Raw Score	98-Item MARS-A Raw Score
N	Valid	27	27
	Missing	0	0
	Mean	147.96	216.15
Percentiles	50	151.00	201.00
	60	153.80	225.00
	75	159.00	236.00

Table 10: Percentiles for Career Choice Survey, and 98-Item MARS-A for the Interviewed Students

Statistics

		CCS Raw Score	98-Item MARS-A Raw Score
N	Valid	11	11
	Missing	0	0
	Mean	152.73	233.18
Percentiles	50	158.00	226.00
	60	162.20	233.40
	75	166.00	288.00

The results from the Career Choice Survey and the 98-Item MARS-A established that more than half of the entire sample had significant levels of mathematics anxiety. Half of these students had low levels of mathematics and career efficacy. Knowing that many of the students studied had significant levels of mathematics anxiety helped to frame the interview questions to be asked of the 11 students interviewed. The responses to these interview questions helped to provide meaning to the significant levels of mathematics anxiety and low levels of mathematics and career efficacy of the students in the study.

Based on the 9th grade normative data 8 out of the 11 (73%) students interviewed scored in the moderate to high range of mathematics anxiety. This indicated that most of the students interviewed had significant levels of mathematics anxiety. Examining the entire sample, it was found that more than half of all the students had significant levels of mathematics anxiety (14 out of 27 for 52%).

Comparing the 8 out of 11 interviewed students who scored 201 or higher on the 98-Item MARS-A, which indicated moderate to high levels of mathematics anxiety, with their scores on the Career Choice Survey, it was found that these students scored below the 50th percentile on the Career Choice Survey. This indicated low mathematics and career efficacy. Almost all of the interviewed students had significant mathematics anxiety and low levels of mathematics and career efficacy. Refer to Table 11. As shown in Table 12, fourteen students (52%) from the entire sample scored above 201 on the MARS-A and below the 50th percentile on the Career Choice Survey, indicating that these students had significant levels of mathematics anxiety and low levels of mathematics and career efficacy.

Table 11: Case Summaries of the Interviewed Students Scoring 201 and Above on the 98-Item MARS-A

Case Summaries

		CCS Raw Score	MARS-A Raw Score
1		158	326
2		158	201
3		145	347
4		137	233
5		169	235
6		166	288
7		112	221
8		127	226
Total	N	8	8

a Limited to first 100 cases.

Table 12: Case Summaries of All Students scoring 201 and Above on the 98-Item MARS-A

Case Summaries

		CCS Raw Score	98-Item MARS-A Raw Score
1		158	326
2		153	292
3		158	201
4		141	219
5		145	347
6		137	233
7		149	226
8		137	274
9		155	236
10		169	235
11		166	288
12		107	350
13		112	221
14		127	226
Total	N	14	14

a Limited to first 100 cases.

4.4 Student Interview Responses in Relation to Mathematics Efficacy

The students arrived for their interviews directly from their labs wearing their distinctive lab specific uniform. The student interviewee sat next to the interviewer with the tape recorder between them. The interview began with light general conversation to relax the student and to introduce the interview questions (Refer to Appendix G: Interview Questions page 136). From the in-depth student interviews the following patterns were discovered.

4.4.1 Student Experiences of Mathematics Courses in Elementary and Middle/Junior High School.

As a result of their middle school experiences more than half (6) of the interviewed students began to question their ability to be successful in the academic mathematics found in high school, with fewer than half (5) of the students stating that they felt confident in their mathematics ability and up to the challenge.

Three of the 6 students who perceived that high school academic mathematics would become more difficult also did not have positive experiences in mathematics classes in elementary school. One student said he did not have positive experiences in mathematics classes in elementary school and "hated it" (mathematics) in middle school. The second student, when asked if he had any positive experiences in elementary mathematics classes said, "Not really. I wasn't really the brightest. I'm in special education for math. But I tried my best to do the math. I succeeded in some places". When asked about his middle school mathematics class experiences he said that it "was getting harder and harder…but I still just keep trying as best I could. I tried my hardest to get through. I just keep trying real hard." The third student when asked if he had any positive experiences in elementary school mathematics classes likewise said, "Not really". He went on to say that "it's just that I didn't do very well with it. I didn't understand a lot". By the time he got to middle school his reaction to mathematics classes was "I guess (I've) just got to get through it another year".

The 3 other students of the 6, who perceived that high school academic mathematics was going to become more difficult, had positive mathematics experiences in elementary school. But as high school approached their perception of their ability to be successful with academic mathematics was diminished. When the first student was asked if he had any positive experiences in mathematics classes in elementary school he responded:

> I really liked math and stuff. Now that I am seeing that I am going to the big high school I'm starting to get a little worried because of how, what the math is going to be like and everything. So you know it gets me a little bit worried.

When this student reached middle school he found that middle school mathematics classes were not difficult, but when he considered future academic mathematics classes that would be taken in high school he had second thoughts. As he reported:

> Middle school actually is not that difficult but sometimes I have a feeling that it's going to be hard like when we are getting into new subjects and stuff it starts to get a little harder like geometry you know and all this other stuff. So you know it is getting hard.

The second of these 3 students said that in elementary school he "was good at it. I was getting Bs" and in early middle school he "did pretty good" in his mathematics classes. He then added that in middle school academic mathematics classes were "getting a little harder".

The third student also "got Bs" in elementary school mathematics classes saying "I got it pretty easily. I understood it pretty easily." But like the other 2 students when he got to middle school he found that academic mathematics "started getting harder".

Two of the 6 students came to the realization that mathematics "was getting harder and harder" even though they found mathematics was becoming more difficult these 2 students accepted that they had to try to do their best. One said, "I still just keep trying as best I could. I tried my hardest to get through. I just keep trying real hard." The other echoed the first student by saying "I guess just got to get through it another year". These 2 students, though struggling with mathematics, were going to do their best to try to work their way through these challenging courses.

There were, however, 5 students who were confident in their ability to be successful in high school academic mathematics classes. One of these students found late middle school as a time when she had gained "more confidence in math". She had a more difficult time in elementary school mathematics classes but had a more successful experience in middle school. She explained, "at first I was not very good at math but now I am" and that in middle school she had "more confidence in math".

The other 3 students reported that mathematics was "still my best subject", was "easier than elementary school in India", and that "7th and 8th grade were really good years. I had nice teachers". The fifth student said he was "usually ahead of my class. Through middle school I was into pre-algebra while everyone else wasn't".

What was discovered from the student interviews was that the majority (6) of these students reported that mathematics was becoming more difficult as they progressed from elementary through middle/junior high school and into high school. This lessening of mathematics confidence expressed by these 6 interviewed students may be due to a high score on the 98-Item MARS-A and a low score on the mathematics efficacy portion of the Career Choice Survey. If future high school academic mathematics courses were to become difficult for these students, they may believe that they would be incapable of being successful. This may cause them not to enroll in academic mathematics courses thus limiting their career options.

The lessening of student confidence in their ability to be successful in mathematics is indicative of low mathematics self-efficacy. As noted in the research literature there is a significant correlation between low mathematics self-efficacy with high mathematics anxiety. Referring to Table 13, the mean score from the 98-Item MARS-A of the 6 interviewed students who were losing their confidence in their ability in mathematics was 258.33. This score was in the high mathematics anxiety range. In contrast the 98-Item MARS-A mean score of the 5 students who expressed confidence in their mathematics ability was 203, far below the mean score of the entire sample and in the moderate range of mathematics anxiety. As a group the 6 students' low mathematics efficacy may be the result of their high levels of mathematics anxiety. Their loss of confidence in their ability to do academic mathematics may be the result of their high mean score on the 98-Item MARS-A.

The mean score on the Career Choice Survey for the 6 students who were losing confidence in their mathematics ability was 142.67, which was much lower than the mean score of 164.80 for the 5 students who did have confidence in their mathematics ability. The 6 students had a mean score on the Career Choice Survey that was below the 50th percentile of the sample group indicating that these students exhibited low career efficacy. In contrast, the 5 students who were confident in their mathematics ability had a mean score above the 75th percentile on the Career Choice Survey indicating strong career efficacy. Refer to Table 13.

The student's level of mathematics confidence may be affected by mathematics anxiety. The students who were confident of their mathematics ability and indicated that they would pursue academic mathematics in high school scored lower on the 98-Item MARS-A and exhibited high levels of mathematics efficacy.

Table 13: 98-Item MARS-A Mean Scores by Group

Case Summaries		
	98-Item MARS-A	Career Choice Survey
Entire Sample N = 27	216.15	147.96
Interviewed Students N = 11	233.18	152.73
Interviewed Students Losing Confidence N= 6	258.33	142.67
Interviewed Students With Confidence N = 5	203.00	164.80

4.4.2 *Perceptions of Student Mathematics Ability Now and in the Future:*

4.4.2.1 Now. The interviewed students felt the same towards the high school academic mathematics courses they were currently taking as they did about mathematics courses taken in middle/junior high school. One of the 6 students who was losing confidence in her ability to be successful in mathematics in middle/junior high school said that, “I don’t like taking math”. Four other students reported similar feelings as one of them reported that he was “not liking it too much. Math class now I really don’t like it cause the layers added into it all the problems and everything is getting really hard”. The last student while he did not say he liked his current mathematics class did say that he was “some what” comfortable in mathematics class.

The 5 students who felt confident in their ability to do well in mathematics courses in elementary and middle/junior high school all felt as one of them reported, "I enjoy math. It is one of my better subjects". These students expressed their enjoyment of mathematics.

4.4.2.2 *Future.* All but 2 of the students interviewed said that they would continue to take academic mathematics in high school. Two of the students who said they would continue to take academic mathematics qualified their answers. One said "yeah I'll try I guess as best I can because I hopefully take like a statistics course or something". The other student said "yeah I'm gonna try to keep on going through with that". Whereas 1 of the 2 students who did not think they would continue with mathematics in high school remarked, "if I can avoid it I will". The second avoidant student said:

> If I can pass yes, if I can't understand it I would quit it. But it kind of depends if I understand it. Like, its one thing if I understand it. It's easier. Like there are some areas where I understand it and some I don't. Some parts I can do really good on and some other parts my god I can't do it!

4.4.3 *Perceptions of Student Ability to Perform Lab Related Mathematics.* All of the interviewed students reported that they felt confident in their ability to perform the mathematics needed for their trade. Only 2 students expressed some difficulty with their trade mathematics. One student said "It was kind of hard, but now we are going over it at the home school. I'm better at it. I'm pretty good at it. I understand it now". While another student admitted that, "yeah I guess it's not too bad".

The rest of the students were enthusiastic in their responses about their ability to perform the mathematics required in their lab, as the excerpts that follow will demonstrate. One exclaimed, “I can do it”. Another said that, “yes it is relatively easy. I’m not struggling with anything. It’s all fractions stuff so I’m good with that”. A third student enthused, “Yeah I can. It’s not very hard or difficult”. A fourth said that, “the lab that I have I feel I understood it and still do”. Lastly, one said, “I feel confident I mean it’s like we’ve learned for computers binary so I can do the operation steps to figure out the steps for the computer”. These students expressed confidence and pride in their ability to do the mathematics needed for their trade.

There was a correlation between the mathematics ability-level of the lab curriculum and the interviewed students’ level of mathematics anxiety. There were 6 students in labs that required moderate mathematics ability, 3 in labs that required strong mathematics ability and 2 in labs requiring the highest mathematics ability. Analyzing the level of mathematics anxiety as obtained from the 98-Item MARS-A of each of the 11 interviewed students, it was found that for all but 1 student, the level of mathematics anxiety of the student correlated with the level of mathematics ability demanded by the lab curriculum in which they were enrolled. Refer to Table 14 noting that the 60th percentile score on the 98-Item MARS-A was 201 and the 75th percentile was 229.

Table 14: Required Lab Mathematics Ability

		Student Number	Current Lab	Required Lab Math Ability	MARS-A Raw Score	CCS Raw Score	Math Confident
1		1	Industrial Electricity	Strong	326	158	Yes
2		4	Health Occupations	Highest	129	183	Yes
3		7	Carpentry	Strong	192	162	Yes
4		16	HVAC	Strong	201	158	Yes
5		18	Computer Information Service	Highest	167	163	Yes
6		21	Heavy Equipment	Moderate	347	145	No
7		24	Auto Trades	Moderate	233	137	No
8		31	Heavy Equipment	Moderate	235	169	No
9		33	Culinary Arts	Moderate	288	166	No
10		36	Auto Trades	Moderate	221	112	No
11		37	Auto Trades	Moderate	226	127	No
Total	N	11	11	11	11	11	11

The higher the level of mathematics anxiety of the student, the more likely that student was to be enrolled in a lab curriculum requiring lower levels of mathematics ability. One student who did not fit this pattern was a female student from the Industrial Electricity lab, which required strong mathematics ability. She scored in the high mathematics anxiety range on the 98-Item MARS-A. Although she began the year having trouble with the mathematics in her lab, she had gained confidence in her ability to do the required mathematics in her lab as the year progressed.

Both interviewed students who were enrolled in the highest mathematics ability labs had low levels of mathematics anxiety, perceived that they were successful in their mathematics courses, exhibited the strongest mathematics efficacy of those who were interviewed, and were in accelerated mathematics classes. These 2 students said that they would continue to take academic mathematics throughout high school. The 6 students in the labs whose curriculum required moderate levels of mathematics ability reported that they were finding high school mathematics more difficult and that they questioned their ability to be successful in future academic high school mathematics. The 3 students in the labs that required strong mathematics ability all said that they would continue to take academic mathematics in high school.

4.4.4 Parental Encouragement to Pursue Mathematics. Seven of the interviewed students' parents did not actively encourage their sons or daughters to pursue academic mathematics in high school. Three of these students reported that their parents "don't really talk about it" or even "mention it". The other 4 students said that their parents did not specifically encourage them to take mathematics courses but encouraged them in general to do well in school. The first of these 4 students said, "they don't really talk about taking math classes, they just want me to get through it". For this student's parents, mathematics is a subject to be endured. The second of these students said, "my dad doesn't like encourage me he just said I should take them".

The third said, "she wants me to go as far as I can with anything I take". The forth student's parents said, "They encourage me to take any classes that I like or do well in". Note that this student was not encouraged to take classes that were challenging or difficult such as mathematics. This student was encouraged to take courses that the student felt he would be successful in. This kind of parental support may not help the student to persevere in challenging courses that may expand the student's career opportunities. This may cause the student to limit his career options.

Only 4 of the interviewed students said that their parents encouraged them to take mathematics courses. Of these only 1 student's parents strongly encouraged their child to keep going in mathematics even when it became difficult and to seek help when needed. The student said his parents "encourage me to keep going with it & if there is help to accept it". Whereas the other three students' parents although encouraging were not concerned with mastery as much as to do ones best. One student was told by his parents, to "try and do the best that I can". Another student seemed to imply that his mother was somewhat interested in him continuing to take academic mathematics courses. This student said, "I guess yeah, my mom is usually interested in me continuing". This did not appear to be strong parental encouragement to pursue mathematics.

To sum up, according to reports from their children, only one parent of the interviewed students strongly encouraged their child to pursue academic mathematics. The majority of the parents appeared either to weakly encourage or not to encourage their child at all to pursue academic mathematics in high school. This could be a contributing factor in the low levels of mathematics efficacy and high levels of mathematics anxiety found in the students of this study. Without strong parental encouragement these students may not persevere in or pursue challenging mathematics courses, which may limit their career options.

4.5 Patterns Discovered in Relation to Mathematics Anxiety, Efficacy, and Avoidance

The following patterns were discovered from Career Choice Survey, the 98-Item MARS-A and the student interviews.

1. The majority of the students that were interviewed found that mathematics was becoming more difficult as they progressed from elementary through middle/junior high school and into high school. The majority of these students questioned their ability to be successful in high school academic mathematics. This was supported by the findings from the Career Choice Survey where it was found that 5 out of the 11 (45%) students interviewed were enrolled in below level mathematics courses. Well over a third of students in the entire sample were below grade level in the mathematics courses they were currently enrolled in. There was an increase in the number of students who fell below grade level in mathematics from 8th grade to 9th grade.

2. Half of the interviewed students did not have positive experiences in elementary or middle/junior high school and continued to have negative experiences in high school. The other half of these students did have positive experiences in elementary and middle/junior school. Looking to the entire sample a third of the students did not enjoy mathematics in elementary school.
3. All but 2 of the interviewed students said that they would continue to take academic mathematics in high school. Two of these students who said they would continue to take academic mathematics qualified their intent based on whether they felt they would be successful. If they felt that they would not be successful, they may decide not to pursue academic mathematics.
4. All the interviewed students felt confident in their ability to do the mathematics required by their lab. Two of these students however did have difficulty at first with the required lab mathematics but at the time of the interviews they were confident in their ability to do the mathematics required by their lab curriculum. Half of the interviewed students were unsure if they enjoyed doing the mathematics in their lab. Three interviewed students were undecided if they would leave their lab if they were required to take more mathematics to stay in their lab. Analyzing the responses from the Career Choice Survey of the entire sample, more than half of the students did not enjoy doing the required mathematics in their

lab. A third of the entire sample and a third of the interviewed students expressed that they wished they did not need mathematics for their career. A quarter of the sample (half of the interviewed students) wished they were better in mathematics so they could be in the lab they wanted. A fourth of the entire sample wanted to avoid taking mathematics courses, and would leave their lab if they were required to take more mathematics courses.

5. There was a correlation between the mathematics ability-level of the lab curriculum and the interviewed student's level of mathematics anxiety. The higher the level of mathematics anxiety the more likely the student was to have been enrolled in a lab curriculum that required lower mathematics ability.
6. Only 1 parent of the interviewed students strongly encouraged their child to pursue academic mathematics. Considering the entire sample, 25 out of the 27 (93%) students' parents did not encourage their child to take more mathematics courses.
7. 30% of the student participants reported that they did not enjoy taking mathematics in elementary school. These students in 9^{th} grade had the following characteristics:
    a. 63% were enrolled in below grade level mathematics courses.
    b. Their mean score on the 98-Item MARS-A was 247, which indicated high mathematics anxiety.

c. Their mean score on the Career Choice Survey of 136 indicated low mathematics and career self-efficacy.

8. 48% of the entire sample did enjoy mathematics in elementary school. These students in 9^{th} grade had the following characteristics:

   a. 77% of these students were enrolled in grade level or above mathematics courses.

   b. Their mean score on the 98-Item MARS-A was 197 which indicated low mathematics anxiety.

   c. Their mean score on the Career Choice Survey was 257 which indicated high mathematics and career efficacy.

4.6 Student Interview Responses in Relation to Career Efficacy

4.6.1 Parental Approval of Student's Choice of Lab. Every one of the interviewed students reported that their parents supported their choice of lab at the vocational-technical education school. Comments from the students pertaining to parental approval of their lab choice ranged from "they were happy with it" to "they really liked it. Cause we are really like regular school people. We take up basic skills so they really liked the fact that I did this." What was interesting was the number of fathers who reportedly voiced encouragement and support for their child's choice of lab. As one student said "My father also encouraged me to do it, (he) thought it was a great idea". Another student reported that, "My dad knows that since I like construction and heavy equipment and all that stuff that runs on diesel that this would be a pretty good advantage to them." Lastly one student summed up the common parental support for their child's choice of lab/career, "my father felt it was good for me".

4.6.2 Parental Influence on the Student's Choice of Lab. The majority (7) of the students interviewed said they made their choice of lab alone without parental influence. Of these seven students who chose their lab based on self-interest there were two students who had limited parental influence in their choice of lab each saying that, "It was primarily my choice" with one of these two students saying, "you know I thought of it myself…they (parents) didn't force me or anything to get into this. I just felt like I wanted to do something you know just in case something breaks down". The other student explained that, "because I have an interest in this (computers), they (parents) knew I had some talent in computers whatever and that's what I wanted to do".

There were however 4 students who were influenced by their parents regarding their choice of lab. Two of these students said that their parents "somewhat did (influence their choice) but not as much" or "they helped me a little bit but most of it was my choice". Both said that the final decision of which lab to enroll was theirs alone. The other 2 students said that their parents actively suggested which lab to enroll in or not to enroll in. One of these students said that his parents "wanted me to see if I would pick something different since my brother already took diesel I just went with it because I really liked it and they were alright with that". The other student said:

> My dad wanted me to choose something else because my brother is already a mechanic. He said there should be like someone else, my brother works in construction, another brother works as a mechanic, my sister is a photographer like graphic arts and stuff. My dad works with computers.

4.6.3 Student Lab Choice Process. The interviewed students were split in how they chose their lab. Some students grew up being influenced by their parents' trade while others made their choice of lab based solely on their own self-interest. One student exemplified the combination of both parental influence and self-interest. This student "wanted to go into auto mechanics cause I always wanted to work with my hands". But he went on to say that he "always wanted to follow in my father's footsteps because he used to work on mechanics stuff. So I always wanted to follow my dad". Even though this student wanted to emulate his father, his decision to go into Power and Transportation was "primarily my choice you know".

Half of the students chose their lab based on their self-interest in the lab curriculum whereas the other half chose their lab based on family or friend's advice. The students who chose their lab out of self-interest expressed their strong interest in the subject matter of the lab. As one of these students said, "I would like to learn electricity and home electricity. I like to learn about electricity. I like it." Another student chose his lab because:

> I just wanted to learn how to like build and fix my car. So I wouldn't have to take it into a shop to get it fixed. If I knew how to do it I would just fix it myself. I work at a garage and I can just take it over there and work on it.

A third student took a look at the current job market and decided to hedge her chances and chose a lab that would offer her a choice of career paths. She chose her lab:

> because right now I see there are more and more jobs opening in nursing than the other stuff. And I was pretty interested in becoming a dentist. So I picked nursing and I take it all together so I could see which one is better.

When she graduates from the vocational-technical education school she will be prepared to continue her education in either the nursing or dentistry field.

The only student who was influenced by a friend in choosing his lab said:

> I choose CIS because I heard from a friend of mine who took the course and he liked it. I heard about (the vocational-technical education school) through my brother. I knew I liked the atmosphere here. And I just have a really high interest in computers.

All of these students had a high level of interest in the lab they chose.

A fascinating similarity was observed between both groups. It was revealed that the interest these students had for their trade area whether influenced by others or from self-interest seemed to be a long-standing interest. For example, one of the students who chose her lab by self-interest said that, "When I was little I always loved to bake and I still do". Likewise, a student who chose his lab based on family influence said:

> It was always in the family pretty much. My brother took the same course. I just like big trucks. Pretty much (since) about 8 or 9 I knew cause I just loved playing with the stuff and work on them.

Another student who was influenced by his father in choosing a lab said, "My dad he works on cars too. So and it just interested me and all the fascinating stuff about cars. I just like it".

A third student was influenced in choosing his lab by his grandfather's work. He explained, "First of all my grandfather owns a business in HVAC and said I could have a job there. I may take that. Basically family influences and stuff." These three students all grew up around the trades their fathers and grandfathers were practicing. These students from very early on had an interest in the lab they chose.

4.7 Findings from the Student Interviews in Relation to Career Efficacy

Analysis of the interview responses related to career efficacy and the data collected from the career efficacy component of the Career Choice Survey gave meaning to the following discovered patterns.

1. All the students interviewed said that they had parental support for their choice of lab and their choice to attend the vocational-technical education school. Almost the entire sample (93%) said their parents supported their career plans. A significant portion of the sample (more than

80%) said that their parents supported their decision to enroll in the vocational-technical education, that they talked with their parents about their career plans, and that their parents wanted them to go to college or a trade school after graduation.

2. All the interviewed students expressed that they were happy with their choice of lab. Turning to the entire sample, the majority (82%) of the participants were motivated to go to the vocational-technical education school to reach their career goal. However, a quarter of the entire sample did not enroll in the vocational-technical education school to reach their career goals. Most (75%) of the sample said that their grades in academic classes in middle/junior high school were good. A third of the female students said that they would have stayed in their sending school and would go to college if they were better in their academic classes.
3. All of the interviewed students freely chose their lab. Although some of the interviewed students explained that their parents exerted varying levels of influence on their decision of choice of lab, all but two of the students said that the final decision was theirs alone.
4. All the interviewed students expressed a strong interest in the career field they chose. Almost all (85%) of the entire sample, said that they had a career plan, which indicated that most of the students in the study

showed strong career efficacy in their choice of lab. More than half of the entire sample plan to go to college or trade school after graduation and will work in their career. Most (67% - 100% for females) said they knew what kind of work they would do when they graduate.

5. Half of the students scored in the moderate to high range of career efficacy on the Career Choice Survey. Almost a third of the entire sample and a third of all the females said that they decided to go to the vocational-technical school to get away from their sending school.

4.8 Interpretation

The student's confidence in their ability to be successful in high school mathematics may be influenced by their level of mathematics anxiety and mathematics and career efficacy. The interviewed students who were losing confidence in the ability to do well in high school mathematics had high levels of mathematics anxiety and low levels of mathematics and career efficacy. The interviewed students who were confident in their ability to be successful in high school mathematics had low levels of mathematics anxiety and high levels of mathematics and career efficacy.

The student's perceived level of confidence in their mathematics ability may have influenced the student's choice of lab. There was a correlation between the interviewed student's level of mathematics anxiety and the ability level of the mathematics required in the lab curriculum. The higher the interviewed student's level of mathematics anxiety the more likely that student was to be enrolled in a lab curriculum that required lower mathematics ability. Mathematics anxiety may be a contributing factor in these students having low mathematics and career efficacy. The students exhibiting low mathematics efficacy may not take the required mathematics courses for their career as they progress through their high school education or pursue careers demanding high mathematics ability.

Half of the entire sample can be described as having significant mathematics anxiety and low to moderate career efficacy. Less than half (44%) of the entire sample reported that they enjoyed doing the mathematics in their lab. The remaining half (56%) of the entire sample may, as they progress through high school, find that the required mathematics courses for their trade or post-secondary education may become too challenging to pursue. This may cause these students to change their career goals. The low levels of mathematics efficacy may be a result of the moderate to high levels of mathematics anxiety of the majority of the students in the study.

The results from this study seem to indicate that negative experiences in mathematics classes in elementary school may affect the students' level of mathematics anxiety and mathematics and career efficacy. 63% of the students who did not have enjoyable experiences in mathematics classes in elementary school found that when they reached the 9^{th} grade were enrolled in below grade level mathematics courses, had high levels of mathematics anxiety, and low levels of mathematics and career efficacy.

In contrast, 77% of the students who reported that they did have enjoyable experiences in mathematics classes in elementary school were found in 9^{th} grade to have been enrolled in grade level or above in their mathematics courses, had low mathematics anxiety, and had high mathematics and career efficacy.

Parental support was strong for the students' choice of lab and career, but limited for encouraging students to pursue mathematics courses. The strong parental support for the students' career choices may explain the high levels of career efficacy of the student's choice of lab whereas the little or lack of parental support to pursue mathematics courses may explain the low level of mathematics efficacy and the moderate to high levels of mathematics anxiety in the students. Without strong parental support encouraging the student to pursue mathematics, the student may not see the value in persevering through challenging mathematics courses and in pursuing careers demanding high levels of mathematics ability. This may be a contributing factor to the students' mathematics anxiety and avoidance.

Although the entire sample exhibited high career efficacy in choosing their lab, only half of the students scored in the moderate to high level of career efficacy on the Career Choice Survey. Almost a third of the entire sample and a third of all the females said that they decided to go to the vocational-technical school to get away from their sending school. Most (73%) of the interviewed students and half of the entire sample had significant mathematics anxiety. Of the interviewed students who had significant mathematics anxiety most (73%) also had low levels of career efficacy. Of the students from the entire sample who had significant mathematics anxiety (52%), half of these students also had low career efficacy.

Even though all the students interviewed expressed strong career efficacy in the choice of lab only slightly more than half (62%) of the entire student sample said that they would work in their career field after graduation. The remaining 38% may be exhibiting low levels of career efficacy and may not have a strong career focus. These students may be enrolled in their lab for reasons other than meeting their career goals even though these students reported that they were glad they were enrolled in their lab.

Chapter 5: Discussion

5.1 Introduction

Early adolescence is the time when students make important decisions about life and career. For some students, early adolescence starts the beginning of a downward spiral of academic failure. A decline in their grades negatively impacts their self-esteem; which in turn has a negative effect on their motivational orientation toward school (Eccles et al., 1993). Lewis (2000) found that some students choose high school vocational-technical education as a consequence of many years of unsuccessful educational experiences, which have persuaded them not to aspire to college.

The vocational-technical education students in this study had inconsistent strengths and weaknesses. They were strongly supported by their parents in their vocational lab choice but at the same time, not supported in pursuing academic mathematics in high school. The majority of the students enjoyed the lab they chose but disliked doing the mathematics required of their trade. All of the interviewed students reported that they were confident in their ability to do the required mathematics in their lab but more than half of these same students reported that they were losing confidence in their ability to do high school academic mathematics. This paradoxical situation could be the result of the significant levels of mathematics anxiety exhibited by the majority of the students in this study.

5.2 Mathematics Anxiety, Course Selection, Career Choice, and Parental Support

This section addresses the following areas in relation to the study of mathematics anxiety:

1. Course Selection
2. Career Choice
3. Parental Support

5.2.1 Course Selection. Most (73%) of the interviewed students in this study had significant mathematics anxiety and scored below the 50^{th} percentile on the Career Choice Survey, indicating low mathematics and career efficacy. The majority (56%) of the entire sample who reported that they did not enjoy doing the mathematics in their lab may find, as they progress through high school, that the required mathematics courses for their trade or post-secondary education may become too challenging to pursue. Mathematics anxiety could be a contributing factor in these students' low levels of mathematics and career efficacy, and may be preventing them from enjoying the mathematics required in their lab.

The research of Aiken (1970) and Hembree (1990) found that mathematics anxiety steadily increases through junior high school and peaks in 9^{th} and 10^{th} grades. It is possible that the students in this study, who had moderate to high levels of mathematics anxiety, could be reaching their peak of mathematics anxiety as exhibited by their low levels of mathematics and career efficacy. More than half of the interviewed students began to lose confidence in their ability to be successful in high school academic mathematics courses as they entered 9^{th} grade.

The transition from 8th grade to 9th grade saw an increase in the number of students whose performance fell below-grade level in mathematics. Forty-five percent of the interviewed students and 37% of the entire sample enrolled in below grade level mathematics courses.

The high levels of mathematics anxiety may explain substantial the increase in the percentage of students enrolled in below grade level mathematics courses in 9th grade (37%) from 8th grade (22%). The effect of mathematics anxiety is often lower mathematics achievement as suggested by lack of confidence and enrollment in low-level courses (Clute, 1984). Although these students did not verbalize that they were mathematics anxious they did exhibit similar behaviors to people who are anxious about studying mathematics, such as taking lower level courses and not wanting to take mathematics courses at all (Richardson & Suinn, 1972).

With 37% of the students below grade level in mathematics, the study results support the research literature which reported that a high percentage of students in high school are not at grade level in mathematics performance when they enroll in college (Battista, 1999). Thirty-seven percent of the students in the study said they wished they didn't need mathematics for their career and 22% of the students said they never want to take another mathematics course. As the students' level of confidence in their mathematics ability decreases, some of the students in this study reported that they might stop taking mathematics in 10th grade reflecting the findings of Lent et al., (1993) that many students stop taking mathematics in 10^{th} grade.

The students who reported that they might avoid enrolling in academic mathematics courses had significant levels of mathematics anxiety. This is congruent with the research literature that found avoidance to be a core constituent of anxiety (Friman et al., 1998). As Betz (1978) and Zettle & Houghton (1998) found, the higher the level of mathematics anxiety, the more likely the student is to avoid mathematics-related tasks, courses or careers which will limit their career choice. Dick & Rallis (1991) found that the high school vocational-technical education student tends to be less prepared in the number and level of mathematics courses taken.

5.2.2 Career Choice. Bandura (1989) and Brown (1999) found that student self-disbeliefs will self-limit career development. These self-disbeliefs may not be the result of the students' inability to do the mathematics necessary for their career but are the result of their perceived lack of ability. By deciding not to develop and widen their career interests and competencies, these self-disbeliefs may validate the students' narrow career options. These self-disbeliefs may influence the student's interests which may then affect their career choice (Ferry et al., 2000; Lent et al., 1994).

It was found that the interviewed students who were enrolled in the labs that required high-level mathematics ability scored low on the 98-Item MARS-A, thus indicating high mathematics efficacy. They reported that they did well in mathematics courses in elementary and middle/junior high school, and intended to take academic mathematics courses in high school, thus demonstrating that these respondents had high mathematics self-efficacy. In contrast, the students in the labs that required moderate mathematics ability scored in the moderate to high-level range of mathematics anxiety. They reported that as they progressed through middle/junior high school they found that the mathematics courses they were enrolled in were becoming more challenging.

The interviewed students who were enrolled in moderate mathematics ability labs reported that they were starting to have trouble understanding the academic mathematics concepts presented in their current mathematics courses and that they were losing confidence in their perceived ability to be successful in future academic mathematics courses. It is likely that these students will not take the required mathematics courses for their trade or career as a result of their low confidence level, and thus will be unable to achieve their stated career goals. These students' exhibited low mathematics self-efficacy could be caused by mathematics anxiety.

The students who did not have positive experiences in mathematics classes in elementary and middle/junior high school may have their current beliefs concerning mathematics affected by these earlier experiences. As Ferry et al. (2000) found, a student's learning experience significantly influences self-efficacy and also outcome expectations. In addition, a student's mathematics related attitude affects course and career choices involving mathematics (Watt, 2000).

The process of choosing a lab in which to enroll may provide students the opportunity for self-selection into a lab curriculum where they feel confident in their ability to do the required mathematics. The majority of the students from the study sample expressed confidence in their ability to do the required mathematics in their lab. At the start of the students' trade skill development in 9th grade, the lab curriculum may require lower level mathematics skills in comparison to the advanced mathematics concepts taught in high school academic mathematics courses. The students in 9th grade may believe that the level of mathematics found in the 9th grade lab curriculum is the extent of the mathematics necessary to be proficient in their chosen trade. As they progress in their training through high school it is probable that they will find that the lab curriculum will demand higher levels of mathematics ability. The majority of students who experienced moderate to high levels of mathematics anxiety in 9th grade may not feel sufficient confidence in their ability to understand the advanced trade mathematics required as they progress in their training through high school.

While the students, who in 9th grade expressed confidence in their ability to do the lab-required mathematics, were satisfied with their choice of lab, these same students did not enjoy doing the required mathematics in their lab. These students may find that the full effect of their mathematics anxiety on their career choice may not impact their course and career choice until later in high school when the lab curriculum's required mathematics reaches advanced levels. At that time, they may find that they are losing confidence in their ability to do the mathematics required by their lab curriculum, rather than academic mathematics courses.

5.2.3 Parental Support. There was limited parental support encouraging students to take academic mathematics courses in high school. Only one of the interviewed students was strongly encouraged by their parents to pursue an academic mathematics high school curriculum. None of the parents of the interviewed female students encouraged their daughters to take academic mathematics. This lack of parental encouragement could be a contributing factor in the low levels of mathematics efficacy and the moderate to high levels of mathematics anxiety found in the majority of students in this study – and suggests that high school guidance counselors could provide an important service to students at vocational-technical education high schools by holding seminars for parents educating them about the increasing mathematical underpinnings of current technical careers. Vocational-technical education teachers would also benefit from becoming aware of their students' level of mathematics anxiety so that they may provide their students with the opportunity to alleviate their anxiety levels. This may increase student retention or recruitment in the trade area lab.

Research has found that parental support is vital in improving student achievement and in changing their interest and achievement patterns (Ferry et al., 2000; Juang & Silbereisen, 2002; Otto, 2000). Perhaps the lack of articulated parental encouragement to take academic mathematics courses might contribute to the lessening of confidence in the mathematics ability of some of the students. From the research of Aiken (1970), Ferry (et al., 2000), Fotoples (2000), and Stuart (2000) students have higher mathematics grades when they perceive their parents are encouraging their efforts in mathematics. This would also appear to suggest that students who receive parental support in taking advanced mathematics courses have expanded career choices available to them.

The strong parental support for the students' career choices may explain the high level of career efficacy of the students in choosing their lab. The limited or lack of parental support to pursue academic mathematics courses may explain the low level of mathematics efficacy and the moderate to high levels of mathematics anxiety in many of the students. Without strong parent support encouraging the student to pursue academic mathematics, the student may not see the value in persevering through challenging mathematics courses and or pursuing careers demanding high levels of mathematics ability.

5.3 Summary of Results

1. The negative correlation between the Career Choice Survey and 98-Item MARS-A seems to indicate that mathematics anxiety may contribute to some of the students' low levels of career and mathematics efficacy. The students who exhibited high levels of mathematics anxiety and low mathematics and career efficacy may not take the required mathematics courses for their career. This may cause these students to change their career goals.

2. The interviewed students who exhibited moderate to high levels of

mathematics anxiety were enrolled in labs that required moderate mathematics ability and were less confident of their ability to be successful in high school academic mathematics. In contrast, the interviewed students with the lowest levels of mathematics anxiety were enrolled in labs demanding stronger mathematics ability, had positive experiences in mathematics courses in elementary and middle/junior high school and intend to continue taking academic mathematics in high school. The interviewed students' level of confidence in their ability to be successful in high school mathematics may be the result of the students' level of mathematics anxiety and mathematics and career efficacy.

3. There was limited parental support encouraging students to take mathematics courses in high school.

4. There was strong parental support for the students' choice of lab and career.

5. The transition from 8^{th} to 9^{th} grade was difficult for many of the students in the study. There was an increase in the number of students enrolled in below level mathematics classes in 9^{th} grade from 8^{th}.

6. More than half of the interviewed students found high school academic mathematics was becoming more difficult and reported that their level of confidence in their ability to be successful in high school academic mathematics diminished as they entered 9^{th} grade. These students might avoid taking challenging mathematics courses in the future, which may affect their course and career choice.

7. More than half (56%) of the participants in the study said that they did not enjoy doing the mathematics required in their lab. Even though all the students felt confident in their ability to do the required mathematics in their lab, if these students who are already finding that they did not enjoy doing the required mathematics in their lab, encounter challenging mathematics required in their lab curriculum, may as a result, decide not to preserver and not to pursue their career path.

8. 63% of the students who did not enjoy mathematics in elementary school were enrolled in below grade level mathematics courses. Had high levels of mathematics anxiety and low levels of mathematics and career efficacy in the 9th grade.

9. 77% of the students who had enjoyable experiences in elementary school were enrolled in grade level or above, had low levels of mathematics anxiety and high levels of mathematics and career efficacy.

5.4 Conclusion

1. Decisions made during adolescence have important implications on vocational development (Bregman & Killen, 1999) and seem in some ways to be irrevocable (Powlette & Young, 1996). They include decisions concerning which academic courses, training, or career to follow (Powlette & Young, 1996). Osipow

(1983) found that the attitudes and values formed during adolescence are important influences on future career behavior (Koski & Subich, 1985). A negative experience 1in a particular academic course like mathematics during the critical years of adolescence can prevent an adolescent from making career choices that involve work in that particular domain (Anderman, 1998) such as a career or trade utilizing mathematics. Course choices made by adolescents in late middle school and early high school can have a profound effect on the direction of their careers and their life.

Therefore, a student's mathematics-related attitude may strongly affect mathematics-related course and career choices (Watt, 2000). Since most of the students felt that they were capable of doing the mathematics required in their lab while at the same time not enjoying it, there may be an indication that some students may not persevere in challenging mathematics courses as they progress through high school. If this occurs these students may have decreased career options.

2. The transition from 8^{th} to 9^{th} grade academic mathematics courses seemed to have been difficult for many of the students in this study. The number of students enrolled in below grade level mathematics courses increased in 9^{th} grade from 8^{th} grade. The interviewed students who reported that the mathematics courses they took in middle/junior high school were becoming progressively more difficult reported a loss of confidence in their ability to be successful in current and future academic mathematics courses. As a consequence, some students were not certain if they would continue to take further academic mathematics courses as they progressed through high school.

3. Parental encouragement in mathematics was found to significantly influence student's learning experiences (Dauber et al., 1996; Ferry et al., 2000) and attitude toward mathematics (Aiken, 1970). Students' grades in mathematics were higher when students perceived that their parents were encouraging their effort in mathematics (Ferry et al., 2000). If the parents of the students who found high school mathematics becoming more difficult would actively encourage their children to strive to do their best and to enroll in academic mathematics courses, improved students' mathematics self-efficacy, reduced mathematics anxiety and improved student achievement may occur. This may then widen the career possibilities for the student. Student career efficacy may also be improved through strong parental support of the student's career choice.

The interviewed students reported that they had strong parental support for their lab enrollment decision and had also reported that they enjoyed the lab in which they were enrolled. Strong parental support for a student's choice of careers has been shown to positively affect a student's career efficacy. Parents influence students' career choices more than any one else (Kotrlik & Harrison, 1987; Otto, 2000; Phillips & Imhoff, 1997). Parents should support and encourage their child to pursue academic mathematics as much as they support their child in their career choice.

5.5 Significance of the Study

The significance of this study is in the guidance the results will provide for students, parents, guidance counselors, teachers, curriculum coordinators and administrators in helping students identify and overcome mathematics anxiety's contributing affect in course and career choice. Self-efficacy greatly affects a student's perception of his/her abilities, which then affects course and career choice. As the results from this study indicated, the interviewed students who were losing confidence in their ability to be successful in high school academic mathematics courses tended to be enrolled in labs that required lower mathematics ability. As a result, they may avoid enrolling in higher-level academic mathematics courses or may stop taking mathematics courses altogether. This will affect the students' career path, and ultimately their level of career achievement.

It is imperative that teachers employ effective teaching strategies and that counselors, parents, and students become aware of the effect of mathematics anxiety on the students' mathematics self-efficacy. Early detection of mathematics anxiety and or avoidance will help the student receive and the teacher provide effective teaching strategies that will improve the student's mathematics self-efficacy and thereby widen the student's career choices available to them.

5.6 Implications for Education

Students' perception of their ability to be successful in mathematics courses affects the outcome in those courses and whether they will pursue challenging mathematics courses. Since student perceptions of their mathematics abilities are established in the classroom, it is important that the teachers be aware of the teaching methodology they use, and consciously use methodologies designed to develop students' feelings of mathematical self-efficacy. The teaching methodology used may affect whether the student is successful and whether the student develops mathematics efficacy (Stuart, 2000). For example, high mathematics anxious students may benefit from expository teaching methodology, whereas low-anxiety students may benefit more from discovery methodology (Clute, 1984).

It is also important for teachers to realize the impact they have on their students. Beginning with arithmetic in kindergarten, teachers' own attitudes about mathematics influences students' attitudes (Steele & Arth, 1998). Students tend to internalize the teacher's enthusiasm for teaching mathematics (Jackson & Leffingwell, 1999) and model their attitudes about mathematics on the perceived attitudes of their teachers. Wadlington, Austin and Bitner (1983) found that elementary school mathematics teachers' attitudes could be transmitted to their students (Sherman & Christian, 1999). Good, Biddle, & Brophy (1975) and Rakow, Airasian, & Madaus (1978) found that teacher behavior makes a difference in student achievement (Clute, 1984).

Mathematics anxiety has been shown to have an effect on student learning of mathematics. Unsuccessful classroom experiences causing mathematics anxiety could have the student feeling “mathematics anxious” for twenty or more years (Jackson & Leffingwell, 1999). Greenwood (1984), found that most mathematics anxiety has its roots in the teachers and the way mathematics is taught rather than from the subject of mathematics (Fiore, 1999).

The impact teachers have on the success of the students in their classroom makes it imperative that teachers be aware of the effect mathematics anxiety has on the self-efficacy of their students. According to Sanders and Horn, (1994) and Wright, Horn,and Sanders, (1997), the teacher is the most important factor affecting student learning and that teachers who do not use effective instructional practices will find their students falling further behind in their learning when compared to students who have been taught with effective instructional practices (Marzano, 2003). It is important that teachers be aware of the effect that mathematics anxiety has on their students so that effective teaching strategies can be employed to increase student learning.

Research has found that mathematics anxiety is widespread among elementary school teachers (Howe, 1999). A high percentage of elementary school teachers avoid mathematics and have been found to be mathematics anxious (Fiore, 1999). In fact some elementary-level teachers do not teach mathematics and science every day, because they are not confident in their ability to teach these subjects or because they do not like teaching these subjects (Miller, 1992).

It is important that all elementary teachers make both their students and themselves comfortable with mathematics teaching and learning. If this does not occur, many students will enter secondary school with a negative attitude toward mathematics putting these students at a disadvantage for the 21st century career market (Hadfield & McNeil, 1994). As teachers begin to realize that teaching demands extensive subject matter knowledge (Lloyd & Fryholm, 2000), elementary teachers may then become more comfortable in their ability to teach mathematics.

5.7 Limitations

Though the study utilized a small sample size that has limited the study's generalizability, the in-depth student interviews and the data collected from questionnaires provided significant insights into the course and career choice decision process of the students studied and the practical implications of mathematics anxiety.

5.8 Future Research

Future research could investigate the following questions. Is there a change in student perceptions of their ability to do the required mathematics in their lab from 9th grade to 12th grade? What causes these changes? Do students enroll in a lab based on their mathematics self-efficacy? Do students who have high mathematics self-efficacy choose labs requiring high-level mathematics ability, and do students with low mathematics self-efficacy choose labs requiring lower mathematics ability? Do students have an accurate appraisal of their mathematics ability? How do students develop self-awareness of their mathematics self-efficacy? How can mathematics teachers at any level provide feedback of a student's mathematics efficacy so that the student can improve their level of mathematics efficacy? What roll do guidance counselors play in student mathematics self-efficacy?

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Appendix A: Abbreviated Mathematics Anxiety Rating Scale (MARS-A)

Number:____________________ Date:____________ Score:____________

Please answer the following questions as fully and honestly as possible. Thank you in advance for your participation.

Directions: The items in the questionnaire refer to things and experiences that may cause tension or apprehension. For each item, place a check (√) under the column that best describes how much you would be made anxious by it. Work quickly, but be sure to think about each item.

How anxious…	Not at all	A little	A fair amount	Much	Very much
1. Receiving a math textbook.					
2. Watching a teacher work an algebra problem on the blackboard.					
3. Signing up for a math course.					
4. Listening to another student explain a math formula.					
5. Walking into math class.					
6. Studying for a math test.					
7. Taking the math section of a standardized test, like an achievement test.					
8. Reading a cash register receipt after you buy something.					
9. Taking an examination (quiz) in a math course.					
10. Taking an examination (final) in a math course.					

Items on this scale are copyrighted by Richard M. Suinn. Items are based on the Mathematics Anxiety Rating Scale-A (MARS-A) by Richard M. Suinn. Authorization to use these 24 items or the MARS-A must come from Dr. Suinn: suinn@lamar.colostate.edu

Appendix B: Career Choice Survey

Number:__________________________ Date:_____________

Please answer the following questions as fully and honestly as possible. Thank you in advance for your participation.

BACKGROUND

Age_____ Current Lab_________________________ Sending High School?______________________

In what grade did you decide to go to the vocational-technical education students-tech school? ______

What Middle School were you in last year?________________________________

Circle your gender
Male Female

Circle: Do you have an IEP? Yes or No

What math course are you taking now?_______________ What grade do you think you will get?_____

What math course did you take last year?______________________ What was your grade?_________

List other labs you thought about entering at the voc-tech school and tell the reason why you did not do so.

Lab__________________________ Reason not chosen____________________________________

Lab__________________________ Reason not chosen ___________________________________

Lab__________________________ Reason not chosen ___________________________________

Lab__________________________ Reason not chosen ___________________________________

Items on this scale are copyrighted by Gary Scarpello. Authorization to use these items must come from Gary Scarpello. gscarp@comcast.net

Please rank each of the following subjects with their own ranking from 1 (like) to 10 (dislike). Please **use only one ranking per item**. For example there can only be one item that you like the best (for a rank of 1) and only one item that you like second best (for a rank of 2) and so on. Each item will have their own rank.

1.	Computers	_____
2.	English	_____
3.	Foreign Language	_____
4.	Math	_____
5.	PE/Health	_____
6.	Science	_____
7.	Social Studies	_____
8.	Technology	_____
9.	Art	_____
10.	Music	_____

Would you take the following courses if it were a requirement to stay in your lab?

		Yes	No
1.	Computers	_____	_____
2.	English	_____	_____
3.	Foreign Language	_____	_____
4.	Math	_____	_____
5.	PE/Health	_____	_____
6.	Science	_____	_____
7.	Social Studies	_____	_____
8.	Technology	_____	_____
9.	Art	_____	_____
10.	Music	_____	_____

Directions: Please express your feelings concerning the statements below. For each item, place a check (√) under the column that best describes how you feel about each statement. Work quickly, but be sure to think about each item.

		Very Strongly Agree	Agree	Undecided	Disagree	Very Strongly Disagree
1.	In elementary school I didn't like math.					
2.	I go to the voc-tech school because my girlfriend/boyfriend goes there.					
3.	If I were told I needed to take more math courses to stay in my lab I would do it.					
4.	I wish I didn't need math for my career.					
5.	My sending school counselor helped me with my career plans.					
6.	I enjoy doing math in my lab.					
7.	My parents wanted me to go to the voc-tech school.					
8.	If I were better in my academic classes, I would have stayed at my sending school and would go to college.					
9.	I never want to take another math course.					
10.	My sending school teachers helped me with my career plans.					
11.	I can't do the math needed in my lab.					
12.	I did not do well in my academic courses at middle/junior high school.					
13.	I do better in my lab than in regular academic classes.					
14.	I go to the voc-tech school because my friends go here too.					
15.	I will work in my career field after graduation.					

		Very Strongly Agree	Agree	Undecided	Disagree	Very Strongly Disagree
16.	My parents support my career plans.					
17.	My grades in my academic classes in middle/junior high school were good.					
18.	My lab teacher helps me with my career plans.					
19.	I know what kind of work I want to do when I graduate from high school.					
20.	I decided to come to the voc-tech school to reach my career goal.					
21.	If I were told I needed to take more math courses to stay in my lab, I would leave my lab for a lab that does not need as much math.					
22.	If I were better in math I would have stayed at my sending school and would go to college.					
23.	Math is my worst subject.					
24.	I didn't go to the lab I wanted to because I don't do well in math.					
25.	I can do the math that's needed in my lab.					
26.	I have a career plan.					
27.	My parents want me to take more math courses.					
28.	I decided to go to the voc-tech school because I plan to go to college or trade school when I graduate.					
29.	My parents didn't want me to go to the voc-tech school.					
30.	I avoid taking math courses.					

		Very Strongly Agree	Agree	Undecided	Disagree	Very Strongly Disagree
31.	Math is my favorite academic subject.					
32.	I chose my lab because I know I am not good in math.					
33.	I talked with my parents about my career plans.					
34.	I wish I were better at math so I could be in the lab I want.					
35.	My parents want me to go to college or a trade school after I graduate.					
36.	I go to the voc-tech school to get away from my sending school.					
37.	My math grades in middle/junior high school were good.					
38.	I don't like to do math in my lab.					
39.	I chose my lab because I don't need a lot of math.					
40.	I knew what my career would be before I entered 9th grade.					
41.	I enjoy taking math courses.					

Appendix C: Test Specification for Career Choice Survey Drawn from the Following Sources

Question	References
1.	(Cemen, 1987; Chiu & Henry, 1990; Ma, 1999; Wigfield et al., 1991; Wigfield & Meece, 1988)
2.	(Auster & Auster, 1981; Stuart, 2000)
3.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
4.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
5.	(Farmer et al., 1995)
6.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
7.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
8.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
9.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
10.	(Farmer et al., 1995)
11.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
12.	(Anderman, 1998)
13.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987; Lewis, 2000)
14.	(Auster & Auster, 1981; Stuart, 2000)
15.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987)
16.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
17.	(Anderman, 1998)
18.	(Kotrlik & Harrison, 1987; Lewis, 2000)
19.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987; Lewis, 2000)
20.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
21.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
22.	(Farmer et al., 1995)
23.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
24.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
25.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
26.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987)
27.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
28.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987)
29.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
30.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
31.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)

32.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
33.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
34.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
35.	(Aiken, 1970; Auster & Auster, 1981; Farmer et al., 1995; Ferry et al., 2000; Otto, 2000)
36.	(Lewis, 2000)
37.	(Anderman, 1998)
38.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
39.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)
40.	(Koski & Subich, 1985; Kotrlik & Harrison, 1987)
41.	(Betz, 1978; Fleischner & Manheimer, 1997; Hackett, 1985; Hembree, 1990; Lent et al., 1993; Sherman & Christian, 1999; Steele & Arth, 1998; Zettle & Raines, 2000)

The section that asks the students to rank academic courses from like to dislike was taken from the research of Battista, 1999 and Hembree, 1990. The section of the Career Choice Survey, which asked the students to rank academic courses in order from like to dislike was also derived from the research of Battista, 1999 and Hembree, 1990.

Appendix D: The Reviewers' Comments of the Career Choice Survey

Reviewer	Credentials	Comments
David R. Liggett, Ph.D.	Senior Lecturer in the Program of Workforce Education and Development. Penn State University	"The questions will provide you with data that can be expanded upon for your topic". "I liked the five point scale associated with some of the questions. Five point scales provide a lot of opportunities to crunch numbers".
Patricia F. Eardley	BS in Elementary Education Masters in Counseling Education Secondary and Special Education Certification	Ms Eardley suggested that the statement asking the student what other labs they were enrolled in be re-written to read "List other labs you attended prior to your current lab." Also the demographic item "Lab" on page 1, was changed to "Current Lab". Ms Eardley added 2 subjects, Art & Music, to the list of subjects students are asked to rate in rank order from like to dislike on page 2. MS Eardley liked the 5 categories of the Likert scale because it "runs the gamut…an answer for everyone". Ms Eardley would like to see the end of the statement changed from "a lab that does not require math" to " a lab that does not require as much math" because every lab requires math.
Alan Eardley	Masters in Education in School Psychology Secondary Guidance Counselor Certification BS in Elementary Education Special Education Certification Psychological Examiners Certification	Mr. Eardley made the same comment about statement number 31, as did Ms. Eardley. But he would only add Art to the list of subjects on page one and not Music. Mr. Eardley found two typos that were corrected.
Kathryn Kloss	BS Elementary Education MS in Counseling Education, Secondary Special Education Certification	Aside from finding a typo, Ms. Kloss believed that "there are a lot of restating (statements) but it will help get a more accurate picture of student". She also thought the efficacy categories were good.
Regina Scarpello	BA English Literature and Special Education Special Education Certification	Ms. Scarpello pointed out words that may be above the students' reading level. Words were replaced or statements re-written to improve readability. For example students had difficulty with the words encouraged and discouraged.

Appendix E: Comments on the Career Choice Survey

Thank you for taking the time to complete the survey and participate in its development. In order to determine the quality of the survey I would like your feed back and impressions. Once again thank you for your participation.

		Very Strongly Agree	Agree	Undecided	Disagree	Very Strongly Disagree
1	The survey was too long.					
2	The statements were clearly written.					
3	The survey touched on all the influences that formed my career choice.					
4	The survey touched on all my thoughts and feelings concerning math.					
5	Too many statements were repeated.					
6	I did not get the point of the survey.					

<u>Additional Comments:</u> Please write any other comments or thoughts you have that would help me improve the survey in determining the influence of mathematics on career choice. Is there an influence that was missed? Be honest and thoughtful.

Appendix F: Examples of Mapping of Items from the MARS for Adults to the MARS-A for Adolescents

Item #	MARS	Item #	MARS-A
6	**Buying** a math textbook.	23	**Receiving** a math textbook
7	Watching a teacher work **on** an **algebraic equation** on the blackboard.	24	Watching a teacher work an **algebra problem** on the blackboard.
8	Signing up for a math course.	26	Signing up for a math course.
9	Listening to another student explain a math formula.	27	Listening to another student explain a math formula.
10	Walking into a math class.	28	Walking into a math class.
15	Studying for a math test.	34	Studying for a math test.
22	Taking math section of **college entrance exam**.	43	Taking **the** math section of **a standardized test, like an achievement test.**
26	Reading a cash register receipt after **your purchase.**	47	Reading a cash register receipt after **you buy something.**
32	Taking an **exam** (quiz) in a math course.	53	Taking an **examination** (quiz) in a math course.
33	Taking an **exam** (final) in a math course.	54	Taking an **examination** (final) in a math course.
43	Being given a set of **numerical problems involving addition** to solve on paper.	67	Being given a set of **addition problems** to solve on paper.

Items on this scale are copyrighted by Richard M. Suinn. Items are based on the Mathematics Anxiety Rating Scale-A (MARS-A) by Richard M. Suinn. Authorization to use these 24 items or the MARS-A must come from Dr. Suinn: suinn@lamar.colostate.edu

Appendix G: Interview Questions

1. Can you tell me a positive and a negative experience of learning mathematics in elementary school?
2. Can you tell me a positive and a negative experience of learning mathematics in middle school?
3. Do you like to take mathematics classes?
4. Do you know what kind of mathematics you need for your lab?
5. Do you think you will be able to do the mathematics required in your lab?
6. Is there a lab you want to take but feel you can't do the mathematics required?
7. What were your reasons for choosing your lab?
8. What were your parents' thoughts about your choice of lab?
9. Did your parents encourage you to take mathematics courses?

Appendix H: Letter to Parents

February 12, 2004

Dear Parent or Guardian:

This letter is in support of Mr. Gary Scarpello who is a mathematics and social studies teacher at North Montco Technical Career Center and who is conducting research at our school to fulfill Ph. D. graduation requirements at Drexel University.

Mr. Scarpello's study is of great interest to his colleagues and to our school community as a whole because it is concerned with course and career choices our students must make. His study may offer students, parents, guidance counselor, teachers, curriculum coordinators, and administrators valuable information that may help students identify their course and career choice process and also impact the teaching process.

North Montco Technical Career Center students currently in the 9th grade are being asked to participate in this important study. Mr. Scarpello, the researcher, does not teach 9th grade and therefore none of the students in the study are students of Mr. Scarpello. Mr. Scarpello will administer the questionnaires and conduct the interviews.

No personal information about your child will be collected in this study. Your child's responses will be anonymous. Students who wish to participate in the study will be asked to spend 10 minutes to complete 2 questionnaires in their lab. In addition 10 of the students who do complete the questionnaires are asked to be interviewed for an in depth exploration of course and career choice.

If you would like your child to participate in this study please have your child sign the **DREXEL UNIVERSITY ASSENT FORM FOR CHILDREN/MINORS IN A RESEACH STUDY** and you as parent or guardian, **please sign** and **initial each page** of the **DREXEL UNIVERSITY CONSENT/PERMISSION TO TAKE PART IN A RESEARCH STUDY.** Please have your child return both signed forms to their Lab teacher.

NOTE: Your child's participation, or lack of participation, in this study will in no way affect their grade at the school. You may discontinue participation at any time without prejudice. All data collected, audio tapes, transcripts of this study will be kept on Drexel University property and will be destroyed at the conclusion of the study.

I am pleased that Mr. Scarpello is conducting this study at our high school. We look forward to reading his findings.

Thank you in advance for your support and participation in this important research.

Sincerely,

Director
North Montco Technical Career Center

Vita

Gary Scarpello
Dresher, PA 19025
May 5, 1953

Education

Drexel University, Phila., PA	Ph.D. Educational Leadership Development & Learning Technologies
Philadelphia University, Phila., PA	Master of Science in Instructional Technology
Gwynedd-Mercy College, Gwynedd, PA	BS Mathematics/Computer Science: BA History
Penn State University, St. College, PA	BS Individual and Family Studies/Adolescence
Maxwell Institute, Norristown, PA	Programming Certificate

Certification

Instructional II Secondary Mathematics, Social Studies and Computer Technology
Certified Network Technologist
Programming Certificate from Maxwell Institute

Teaching Experience

North Montco Technical Career Center, Lansdale, PA	Mathematics; Computer Information Science Technology; Social Studies
Sleighton School, Glen Mills, PA	Computer Science; Mathematics; Social Studies
Wallingford-Swarthmore School District Adult School Wallingford, PA	Adult Education: Computers
PJA Business School, Upper Darby, PA	Adult Education: Computers
Wordsworth Academy, Ft. Washington, PA	All grades and subjects K-12
Wyncote Academy, Wyncote, PA	All subjects secondary level

Computer Experience

Consulting	**Duties:** Design, implement and supervise network, hardware, and software installations. Troubleshoot and coordinate repairs. Configure and support central databases. Design training materials. Design and lead staff training sessions. Web Page design.
Network Administrator North Montco TCC Lansdale, PA	**Duties:** Designed, implemented and supervised network, hardware/software installations and repairs. Managed everyday functions of the network. Supervised central database teams. Designed training materials and led training sessions. Supported and implemented software/hardware upgrades. Web Page design.
Network Administrator Sleighton School Glen Mills, PA	**Duties:** Designed, implemented and supervised network installations connecting 22 buildings to a fiber-optic backbone. Managed the everyday functions of the network. Supervised training staff of mentors and central database teams. Designed training materials. Led training sessions. Supported software and hardware. Trouble-shooted and coordinated repairs.

Professional Organizations

National Council of Teachers of Mathematics
Instructional Materials Services Advisory Council for Montgomery County
Internet Advisory Council for Montgomery County
Mathematics Council of Montgomery County
Correctional Education Association
Mathematical Association of America
National History Honor Society

Conference Presentations

Conference on Integrated Learning: The School-to-Career Connection
Correctional Education Association State Conference

Interests

Travel	Mexico, Caribbean, U.S., Canada, England and Wales
Photography	Still life work exhibited in galleries
Film	Directed and produced films aired in the tri-state area
Music	Original music reviewed in national publication and aired over many stations including WHYY and WMMR
Recording Engineer	Album credits on world releases
Television	Cameraman, summer relief technician for local stations and commercial houses including WCAU TV-10 and WHYY TV-12
Radio	Disc Jockey/Promotion Director college radio stations