ANALYSIS OF THE INTERRELATIONSHIPS BETWEEN SCIENCE ANXIETY
AND THE VARIABLES OF GENDER, COURSE OF STUDY, PARENT
BACKGROUND, ACHIEVEMENT, TEST ANXIETY, AND ATTITUDE TOWARD
SCIENCE

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of the Ohio State University

By

Carol A. Hensley, B.S., M.A.

*****
The Ohio State University
1996

Dissertation Committee:

Arthur L. White, Ph.D.
James W. Altschuld, Ph.D.
David L. Haury, Ph.D.

Approved by

Advisor
College of Education
Copyright by
Carol A. Hensley

1996
ABSTRACT

The purpose of this exploratory study was to determine those variables that best predict or relate to science anxiety. The variables investigated were gender, course of study, parent background, achievement, test anxiety, and attitude toward science. One hundred sixty six students in Microbiology and Biology courses at a major university were given the instrument designed to obtain information on the variables mentioned. This instrument included Spielberger's Test Anxiety Inventory and the Czerniak Assessment of Science Anxiety by Czerniak and Chiarelott. The variables found to be predictors and explain science anxiety best were test anxiety, attitude toward science, parent background, and gender. Attitude toward science was further explained by choice of major, parent background, and taking optional science courses. Major findings include the following relationships. Those with high test anxiety tend to have high science anxiety. Positive attitudes toward science indicate lower levels of science anxiety. Parent education level and/or occupation related to student attitude toward science, most likely through the parent’s attitudes toward science. Finally, females tend to have more science anxiety than males. Implications of these findings for practice and for further research are also provided.
To

James, Mom, Dad, Joanna, and Nancy

for your ever present support and encouragement
ACKNOWLEDGMENTS

I would like to thank Dr. Arthur L. White for his advice, support, and guidance throughout my research. The assistance and encouragement from the other members of my advisory committee, Dr. James W. Altschuld and Dr. David L. Haury was also greatly appreciated. I would also like to thank Dr. Stanley L. Helgeson and Dr. Kathleen Kendrick for their participation in my educational endeavor. To my parents, sisters, other family members and friends, thank you for all your support and encouragement. Finally, to my husband, James, thank you for all your understanding, patience, encouragement, and sacrifice which enabled and helped me to complete this project and my education.
VITA

May 31, 1967

Born, Silver Spring, MD

1990

B.S. Biochemistry,
Virginia Tech,
Blacksburg, VA

1991-1995

Graduate Research Associate,
National Center for Science
Teaching and Learning,
Columbus, OH

1994

M.A. College of Education,
The Ohio State University,
Columbus, OH

FIELDS OF STUDY

Major Field: Education
Science Education
# TABLE OF CONTENTS

ABSTRACT ........................................................................................................ ii
DEDICATION ...................................................................................................... iii
ACKNOWLEDGMENTS ......................................................................................... iv
VITA ................................................................................................................... v
TABLE OF CONTENTS ....................................................................................... vi
LIST OF FIGURES ............................................................................................. x
LIST OF TABLES ............................................................................................... xi

## CHAPTER 1

INTRODUCTION

Need for the Study ............................................................................................ 1
Theoretical Background ...................................................................................... 2
  Anxiety ........................................................................................................... 2
  Test Anxiety .................................................................................................. 6
  Science Anxiety ............................................................................................ 18
  Summary ....................................................................................................... 25
Statement of the Problem .................................................................................. 26
Definition of Terms .......................................................................................... 27
Research Statements ........................................................................................ 31
Delimitations ..................................................................................................... 32
Limitations ........................................................................................................ 32
TABLE OF CONTENTS (cont)

CHAPTER 2
LITERATURE REVIEW
Introduction .......................................................................................................................... 33
Research ............................................................................................................................... 35
   Measurement - Anxiety ................................................................................................. 35
   Measurement - Test Anxiety ......................................................................................... 39
   Measurement - Science Anxiety .................................................................................... 47
Variables ........................................................................................................................... 48
   Gender ............................................................................................................................. 49
   Course of Study .............................................................................................................. 49
   Parent Background ......................................................................................................... 50
   Attitude Toward Science ............................................................................................... 52
Summary ............................................................................................................................ 52

CHAPTER 3
METHODS AND PROCEDURES
Design ................................................................................................................................. 55
Pilot Study .......................................................................................................................... 56
Full Study ........................................................................................................................... 70
   Sample ............................................................................................................................ 70
   Instrumentation .............................................................................................................. 72
   Data Collection ............................................................................................................. 73
   Data Analysis ............................................................................................................... 73
Summary ............................................................................................................................ 77
CHAPTER 4
RESULTS

Results of the Total Sample ................................................................. 79

Means, Standard Deviations, Reliabilities of the Instruments

Included in the Data Collection ............................................................ 79

Correlational Results ......................................................................... 83

Multiple Regression Results ............................................................... 89

Multiple Linear Regression Analysis .................................................... 89

Stepwise Linear Regression Analyses .................................................. 90

Science Anxiety ................................................................................. 90

Test Anxiety - Worry ......................................................................... 92

Test Anxiety - Emotionality ............................................................... 92

Attitude Toward Science .................................................................. 92

Results of the Achievement Subsample .............................................. 94

Means, Standard Deviations, Reliabilities of the Instruments

Included in the Data Collection ............................................................ 95

Correlational Results ......................................................................... 101

Summary of Results .......................................................................... 106

CHAPTER 5
CONCLUSIONS

Results Summary of the Correlational Study - Total Sample .................. 110

Results Summary of the Multiple Linear Regression Analysis - Total Sample ................................................................. 112

Results Summary of the Correlational Study - Achievement Subsample ........ 117

Conclusions ..................................................................................... 118

Future Research With Implications for Practice ................................. 122
TABLE OF CONTENTS (cont)

LIST OF APPENDICES

Appendix A
   Instrument ........................................................................................................ 130

Appendix B
   Course List and Prerequisites ...................................................................... 139

Appendix C
   List of Occupations ...................................................................................... 168

Appendix D
   Permission Form ............................................................................................ 171

LIST OF REFERENCES ................................................................................... 173
LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>75</td>
</tr>
<tr>
<td></td>
<td>Hypothesized model of science anxiety and the variables gender, course of study, parent background, test anxiety, and attitude toward science</td>
</tr>
<tr>
<td>2.</td>
<td>88</td>
</tr>
<tr>
<td></td>
<td>Summary of the correlation coefficients for the variables GEN, MAJ, MORSCI, Req, OPT, REQTOT, OPTTOT, DADSCI, MOMSCI, DADED, MOMED, SCIA, TAIE, TAIW, and SAI - Total Sample (p \leq 0.001)</td>
</tr>
<tr>
<td>3.</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Summary of the linear regression analysis coefficients for the variables GEN, MAJ, OPT, MOMED, DADSCI, TAIW, TAIE, SCIA, and SAI - Total Sample</td>
</tr>
<tr>
<td>4.</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Summary of the linear regression analysis coefficients for the variables MAJ, OPT, DADSCI, and SCIA - Total Sample</td>
</tr>
</tbody>
</table>
# LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Abbreviations of Instruments</td>
<td>34</td>
</tr>
<tr>
<td>2. Summary of Abbreviations Used for the Instruments, Predictor Variables, and Science Anxiety</td>
<td>57</td>
</tr>
<tr>
<td>3. Coding Scheme Used in All Entry of Instrument Data</td>
<td>60</td>
</tr>
<tr>
<td>4. Descriptive Statistics and Reliabilities (Chronbach's Alpha) of the Instruments Used in Pilot Study</td>
<td>64</td>
</tr>
<tr>
<td>5. Descriptive Statistics of Independent Variables - Pilot Study</td>
<td>66</td>
</tr>
<tr>
<td>7. Descriptive Statistics of Independent Variables - Total Sample</td>
<td>80</td>
</tr>
<tr>
<td>8. Descriptive Statistics and Reliabilities (Chronbach's Alpha) of the Instruments Used - Total Sample</td>
<td>82</td>
</tr>
<tr>
<td>9. Significant Pearson Product-Moment Correlations Between Independent Variables and Science Anxiety - Total Sample</td>
<td>84</td>
</tr>
</tbody>
</table>
LIST OF TABLES (cont)

10. Summary of the Multiple Linear Regression Analysis of the Predictor Variables of Science Anxiety - Total Sample ........................................ 91

11. Summary of the Hierarchical Stepwise Linear Regression Analysis for the Predictor Variables of Science Anxiety - Total Sample ............ 93

12. Summary of the Hierarchical Stepwise Linear Regression Analysis for the Predictor Variables of Attitude Toward Science - Total Sample ............ 94

13. Descriptive Statistics of Independent Variables - Achievement Subsample .................................................................................................... 96

14. Descriptive Statistics and Reliabilities (Chronbach’s Alpha) of the Instruments Used in Study - Achievement Subsample ......................... 98

15. T-test Scores Between the Total Sample and the Achievement Subsample .................................................................................................... 99


17. Findings for the Total Sample .................................................................................................................................................................................. 107

18. Findings Unique to the Achievement Subsample ........................................................................................................................................ 109
CHAPTER 1

INTRODUCTION

Need for the Study

Amid reports of declining achievement scores in science nationally... reduced time allocated for science instruction... and negative student attitudes toward science increasing by grade level, new evidence is emerging that suggests a relationship among these factors and the existence of science anxiety. (Chiarello & Czerniak, 1987, p. 202)

Science anxiety is a danger because of its consequences. Science anxiety leads to science avoidance and science illiteracy. Achievement in science is known to be inhibited by science anxiety. Reduction of science anxiety has been shown to lead to higher academic achievement (Westerback, Gonzalez, & Primavera, 1984). But this is not enough. Achievement, attitude, and understanding must improve. Fort (1993) expressed her concern: "A science shy public served by a science shy Congress could threaten national and global survival." Science anxiety, as indicated by low achievement in science, negative attitudes toward science, and avoidance of enrolling
in science courses, is an area that, though threatening, has little research to direct and assist science educators.

Prior research in this area has focused on the effects of science anxiety on achievement, gender differences, and how science anxiety affects preservice elementary teachers. Many of these studies are also directed toward secondary and post-secondary students, leaving out younger students (Chiarelott & Czerniak, 1987).

Perhaps a reason for the poverty of research is the complexity of the topic. Science anxiety has many components, each of which are complex themselves. These include anxiety in general; test anxiety with its cognitive and emotional aspects; negative self concepts derived from parents, school, and teachers; and negative attitudes toward science with stereotypes and misconceptions as its source.

What is needed is further research into some of these complex factors and how they are interrelated. In understanding these relationships, not only will there be a clearer notion about science anxiety, but perhaps ways to prevent it from occurring can be discovered.

Theoretical Background

Anxiety

Anxiety in general has been a concept of interest for intellectuals in disciplines from philosophy to the sciences for many years. Sartré (1970) defines anxiety as the fear of not achieving a certain standard. Sieber, O'Neil, and Tobias (1977) elaborate this idea:
General anxiety is a more comprehensive construct that refers to the phenomenological, physiological, and behavioral responses that may accompany any event in which the individual perceives that he/she may be unable to deal easily and satisfactorily. (p. 24)

For the purposes of this research, these "standards" as described by Sartré, on occasions concern general student performance in school, and specifically, in courses related to or directly involving science.

Freud (1936) defines anxiety as it develops from punishment and repression. Anxiety attacks occur when fear of punishment is no longer repressed but expressed. Freud also distinguished two types of anxiety - objective and neurotic. Objective anxiety deals with the external environment and results from a danger source found in that environment. Neurotic anxiety is comparable to fear in that it is an internal reaction to some sensed threat, but differs from fear which is dependent on external stimuli. These ideas are similar to those in the Baker Encyclopedia of Psychology (Brennar, 1985), anxiety:

...may be defined as a subjective feeling of tension, apprehension, and worry, set off by a particular combination of cognitive, emotional, physiological, and behavioral caes. It is generally thought to differ from fear in that it is not tied to a realistic threat from the environment. (p. 65)

Neurotic fear is based on a person's history of traumatic events, be they remembered or not. Many times they are repressed due to some accompanying punishment and not remembered at all.
Where Freud believed anxiety was rooted in a person's past, Pekrun (1985) and Bandura (1988) see anxiety in terms of a person's future. Pekrun defines anxiety as "...a future-related emotion which is determined by expectancies of negative future events and the amount of threat implied by these events." Bandura thinks anxiety is an "anticipatory apprehension" over possible threatening occurrences.

Some of the first research that begins to bridge the ideas of anxiety as purely psychological to anxiety being involved with cognition and learning is the work done by Spence and Hull. Hull (1943) and Spence (1958) use Hull's learning theory to develop an explanation of anxiety. This theory describes two concepts which they believe influence performance and, ultimately, learning. These factors affect the probability that learning or a learned response will happen due to a stimulus. This occurrence, called excitatory potential (E) or also referred to as performance (P), is a function of the two factors, learned habit or habit strength (H) and drive (D) in a multiplicative manner:

\[ E \text{ (or } P) = f(H \times D) \]

Habit strength is the tendency that a response will occur and is dependent on the number of learning trials the subject has experienced. Drive relates to the subject's motivation and is affected by stimulus intensity and emotionality of the subject. Emotionality as it is used here is Hull's term for anxiety. These two factors, habit
strength and drive, form the basis of Taylor's Manifest Anxiety Scale (Taylor, 1951, 1953).

Hull and Spence's idea that anxiety is a function of probability to react to threatening stimuli also led to a theory introduced by Cattell and Scheier (1961) and elaborated by Spielberger (1966, 1972). This theory is known as the State-Trait Theory. Trait anxiety is defined by Spielberger as the stable differences in anxiety proneness or tendency to respond to situations thought of as threatening. It is seen as part of the individual's personality. State anxiety is not stable, but a transitory condition characterized by subjective feelings of tension, apprehension, and increased physiological symptoms which fluctuate over time. Cameron's (1947) definition of an anxious patient, "...characterized by the presence of persistently heightened skeletal and visceral tensions..." fits this concept. State and Trait anxieties can be measured by the State-Trait Anxiety Inventory (Spielberger, Gorsuch, & Lushene, 1970). The State-Trait theory makes the assumption that anyone who believes that a situation is threatening will experience an increase of state anxiety whether or not a real danger exists. The duration and intensity of this increase is dependent on the amount of perceived threat. Also, higher levels of state anxiety are produced in those persons with higher trait anxiety than for those with low trait anxiety. This theory is of importance in relation to the educational setting as will be seen due to its connection with test anxiety. Notice the similarities between these models. Trait anxiety is quite similar to the concepts of habit strength and of neurotic anxiety.
Test Anxiety

One semantic note must be made at this time. The terms "anxiety", "test anxiety" and "evaluation anxiety" have been used synonymously in the literature concerning anxiety in an educational setting. However, Sieber, O'Neil, and Tobias (1977) caution that though evaluative anxiety is a form of general anxiety, the overlap is not enough to denote the terms as being synonymous. For example, Sarason (1972) found a significant correlation between test and general anxiety measures and between test anxiety and test performance measures, but not between general anxiety and test performance (Sarason, 1960). Therefore, it is shown that these terms are not synonymous, and term usage must be specified. With that in mind, the rest of this paper will use the term "test anxiety", not as a synonym for general anxiety, but in reference to this concept of anxiety involving any evaluational experience in the educational setting.

Test anxiety has been defined in a variety of ways. It is interesting to note the similarities there are with the previously described definitions of anxiety, especially that given by Cameron. Schwarzer, van der Ploeg, and Spielberger (1982) define test anxiety as a personality trait that is specific to an academic situation where performance is evaluated, and involves individual differences in ways people have feelings of worry in those situations.

Salamé (1984) offers another example of this theme. He states test anxiety is an emotional state where one experiences feelings of apprehension, nervousness, and tension. He adds that this feeling is often accompanied by an autonomic
response which includes symptoms such as sweating and an increased heart beat. Again, there is a connection between this definition and the aforementioned idea of state anxiety.

Besides these general definitions of test anxiety, Liebert and Morris (1967) describe the two components of test anxiety that are considered the backbone from which all other components branch. They call these components worry and emotionality respectively. Basically, worry is the cognitive, "feelings" part and emotionality is the part that is more physical.

Worry is conceptually defined as "any cognitive expression of concern about one's own performance." The concept "worry", described as the significant predictor of achievement expectancy, has been highlighted in other studies since the 1967 Liebert and Morris study. There is a concern that the concept of "worry" be further understood by dividing it into components. Schwarzer and Quast (1985) describe the worry components rather as being types of worry. These include one's coping ability, and worry if it is inadequate. Another is worry about future failure and what happens if one fails. Worry about self worth is yet another type, and finally, there is the worry that leads to irrelevant thinking. This irrelevant thinking takes one's thoughts of matters at hand, such as a test, and instead replaces them with thoughts related to the other types of worry, such as future failure and loss of self worth.

These ideas are paralleled in other studies as well. Salamé (1984) concluded that there are four divisions of worry: doubts of competence, lack of confidence in one's ability to succeed, fear of failure, and fear of failure's consequences on one's
academic career. Jerusalem, Liepmann, and Herrmann (1985) equate worry with fear of failure. Schmalt (1982) differentiates "fear of failure" into two types: FF₁ and FF₂. FF₁ is defined as a self concept of low ability, relating to Salamé's first two divisions of worry. Individuals make sure they fail, and believe that failure to be due to their low ability. Success is attributed to luck. FF₂ is the fear type related more specifically to the consequences of failure.

Covington (1985) cites that "worry is the predominant source of test-taking interference". What about worry makes it so? Covington explains that worry, or "cognitive manifestations of anxiety" such as thoughts about future success, interfere with performance because the individual is preoccupied by those thoughts and not by the task at hand. This echoes Schwartzter and Quast's idea of "irrelevant thinking."

"Worry" in general, and components of "worry" described previously, are seen as factors which provide some of the greatest hindrance to achievement (Sharma & Rao, 1983). Morris and Liebert (1970) found worry to be more negatively related to test scores than emotionality. Morris, Franklin, and Ponath (1983) studied this further. Ninety-nine General Psychology students volunteered for the experiment. They were all given the Test Anxiety Inventory (TAI) about two weeks before their final exam for the course. On the day of the final, they were given a Worry-Emotionality Questionnaire (WEQ) along with the final and were told to complete the WEQ before taking the final. Finals and course scores were recorded. Males and females were matched on the basis of final exam scores to determine if gender was a variable to consider. Results showed that students scoring higher on the TAI were
more anxious and performed less well than those scoring low. Those who scored low were less anxious and their performance was better. It was interesting to note there was no significant differences between males and females.

Hembree (1988) in his meta-analysis of test anxiety research included as one result that "Test anxiety and performance are significantly related at grade 3 and above. The relationships are inverse and tend to be stronger for worry than emotionality." He arrived at this conclusion by determining the correlations of worry and aptitude and emotionality and aptitude from a total of 16 studies. Thirteen of the studies dealt with aptitude or achievement measures, three studies were concerned specifically with a course grade. Hembree found correlations of -0.31 and -0.26 for worry (achievement/aptitude and course grade respectively), and correlations of -0.15 and -0.19 for emotionality. While all correlations were significant at the $p < 0.01$ level, those for worry were nearly double those of emotionality.

In summary, worry is the cognitive aspect of test anxiety. It is characterized by fear of failure, and especially by irrelevant thoughts about failure, low ability, and low self worth which interfere with performance and thus worry may be more of a deterrent to achievement than emotionality.

So what is emotionality? Emotionality is defined as "autonomic reactions which tend to occur under examination stress." Such reactions include a sense of tension (Schwarzer, van der Ploeg, & Spielberger 1982; Schwarzer & Quast, 1985; Zimmer, Hocevar, Bachelor, & Meinke, 1992), nervousness (Schwarzer & Cherkes-Julkowski, 1982), apprehension, (Salamé, 1984), and bodily symptoms such as rapid
heart beat, sweating, and nausea (Schwarzer, van der Ploeg, & Spielberger 1982; Schwarzer & Quast, 1985; Salamé, 1984). This concept of emotionality recalls the general anxiety concept of state anxiety. They both are characterized by the physical symptoms expressed in threatening situations.

Liebert and Morris developed an instrument to measure the presence of these two components of test anxiety. This instrument, called the Worry-Emotionality Questionnaire (Liebert & Morris, 1967) will be described in detail in Chapter Two.

Since Liebert and Morris developed a two-component conceptualization of test anxiety, others have added to it. Deffenbacher (1978) used the drive theory of Hull and Spence mentioned earlier to establish a third component, that of task-generated interference where both symptoms of worry and emotionality compete with the task at hand. This is an addition to the "irrational thinking" aspect of worry, because here Deffenbacher states emotionality, the physical aspects, also interfere.

Deffenbacher studied these three components of test anxiety and how they effected students under "evaluative stress." Deffenbacher concluded that test anxiety produced an interfering anxiety which changed the cognitive focus to thoughts of worry, physiological upset and task irrelevant aspects which drove focus away from "efficient problem solution."

An alternate aspect of task interference is the idea of task avoidance or procrastination. Solomon and Rothblum (1984) examined the relationship between procrastination and possible causes of it. They found there were two groups of procrastinators. One group, much larger in size, reported an aversive behavior. This
group disliked academic activities, were depressed, and had inadequate energy and study habits. The second, smaller group, were more concerned with fear of failure. Later, Rothblum, Solomon, and Murakami (1986) indicate a relationship between procrastination and test anxiety. High procrastinators, those who studied less before exams and who were inhibited by fear of failure, reported higher test anxiety.

Another component of test anxiety is suggested by Sarason (1984). His four-dimensional model of test anxiety includes worry, emotionality (called "bodily symptoms"), "test-irrelevant thinking", and tension. The worry component remains the same in definition. Sarason has separated emotionality into the terms "bodily symptoms" and "tension". Bodily symptoms refer to physical ailments such as headaches or nausea. Tension relates not to physiological symptoms, but to sensations, nervousness, and uneasiness.

It is not clear from the literature why highly test anxious people are so self-focused, worry, and avoid the task at hand. Threat to self esteem may represent one answer. Gaudry and Spielberger (1971) state that people with high trait anxiety will perceive situations involving threat to self esteem as more threatening than those with low trait anxiety. Highly test anxious students perform as well or better than low test anxious students provided the ego threat or evaluative stress is low. The inverse is also true, that low test anxious students perform better than high test anxious students when the ego threat is high. (Sarason, 1963; Sinclair, 1969; Gaudry & Spielberger, 1971; Hembree, 1988).
Suinn and Hill (1964) found a negative correlation between test anxiety and self-acceptance. They see an interpretation of this is that "...anxiety, a state of emotional disturbance, disrupts the person's capacity to relate positively to himself and others." This idea reflects the worry components of doubt of competence and lack of confidence in one's ability. If one does not perform to a certain standard, as Sartré offered, one is not accepted by society.

The pressure to perform feeds into test anxiety. Covington (1985) sees "failure of self" as a source of test anxiety, which relates to the worry component of fear of failure. The evaluation is perceived as a threat to self esteem caused by failure. This failure is dependent on the circumstances surrounding that failure, the importance linked to the failed task, and the degree to which a person is liable to connect their sense of self worth to their accomplishments or failures.

Social aspects of test anxiety have been the subject of much theory and research. According to Rost and Schermer (1989), "audience anxiety", a term coined by Paivio (1965) meaning anxiety caused when one must appear as a speaker in front of classmates and teacher, is closely related to test anxiety due to the ego-threat involved. Stress of the social climate may come in the form of the classroom, the teacher, other students (Schermer, 1982) and self. Schwarzer and Cherkes-Julkowski (1982) studied self-concept of ability, lack of self-confidence, self-esteem, hope for success, social anxiety, test anxiety, and helplessness. Self-esteem and self-concept of ability affected test anxiety to the greatest degree. They also saw self evaluation as "...a critical direct and indirect process" and that "...it is the student's own evaluation
of his work rather than a teacher's praise or criticism which is most influential in the formation of anxiety responses..." Since aspects of self affected test anxiety the most, it seems reasonable that self evaluation was also the most influential as well.

Schwarzer and Lange (1983) studied the development of test anxiety and its relation to the learning environment with respect to competition, achievement pressure, and class chaos. They found that competition and achievement pressure were related to test anxiety. Pekrun (1985) concurred as he concluded in his study of class climate and test anxiety:

...the social climate within classrooms influences scholastic test anxiety, whereby perceived teacher support is alleviating test anxiety and perceived teacher press for achievement, competing between students and a chaotic course of lessons are strengthening it. (p. 158)

Hembree (1988) in his meta-analysis of test anxiety (TA) studies offers two models of test anxiety. The first is what he calls the interference model "wherein TA disturbs the recall of prior learning and thus degrades performance", and the deficits model where low performance is due to inadequate test-taking skills or to deficient study habits, where "...TA does not cause poor performance, the reverse is true. Awareness of poor past performance causes test anxiety." Theories of Mandler and Sarason (1952), Alpert and Haber (1960), Ruebush (1960), Wine (1971), and Spielberger (1972) are illustrations of the first model. Tobias' (1979, 1985, 1992) theory is an example of the second.
Mandler and Sarason (1952) were among the first to advocate the importance of test anxiety. They developed the Test Anxiety Questionnaire (TAQ) a "questionnaire on attitudes toward test situations." Using this TAQ, they studied high anxiety (HA) and low anxiety (LA) subjects. They found that report of success or failure improved performance for the LA group but lowered performance for the HA group. The authors do not state if there was a regression toward the mean affect. Regression toward the mean is a phenomenon where group scores on a second measure are closer to the mean in relation to the first measure.

Sarason (Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960) studied anxiety in children and how it is transferred to the school setting. He theorized that the development of anxiety began in the family setting as a child is constantly evaluated by parents. Anxiety is formed when the child, depending on parents' approval, gets negative evaluations. In school, teachers are seen as parent figures and this evokes a similar anxiety. Sarason utilized the Test Anxiety Scale for Children (TASC; Sarason et al, 1960) generated from the earlier instrument the Test Anxiety Scale (Sarason, 1958) in this study.

Alpert and Haber (1960) studied test anxiety and its effect on achievement. They examined the two types of test anxiety as defined by Liebert and Morris in subjects: facilitating and debilitating test anxiety. Facilitating anxiety is that test anxiety which increases performance levels, and debilitating anxiety is that which hinders performance. The Achievement Anxiety Test (AAT; Alpert & Haber, 1960)
was used to evaluate these anxieties, which are illustrated in the Yerkes-Dodson law (McKeachie, 1977):

As applied to anxiety and performance, the Yerkes-Dodson law predicts that an increase in anxiety results in improved performance and effectiveness up to a point [facilitating anxiety], and that further increases in anxiety result in decrements in performance [debilitating anxiety]. (p. 3)

Ruebush (1960) put these ideas of facilitating and debilitating, or his term, interfering test anxieties together into a model which accounts for their effects. He states that the determination of anxiety effect, whether it be interfering or facilitating, is "mediated primarily by defensive reactions to the anxiety." These defensive reactions, such as cautiousness, can be over-learned in students who tend to be highly anxious and can become automatic to the point where they always occur in situations causing the test anxiety. If the defenses are helpful, the effect is facilitating. If the defenses are not, the effect is interfering.

Wine (1971) uses the idea of task irrelevant thinking or task interference discussed by Deffenbacher (1978) to explain how test anxiety harms performance. In her review of the literature, she concludes that highly test-anxious people lose attention to task during situations of performance evaluations. They are generally self focused and dwell on thoughts of self evaluative worry, and self-criticism. The result is poorer performance.

Spielberger's (1972) theory of state and trait anxiety was described previously. It can be related to test anxiety in respect to how state and trait anxieties
are manifested in the evaluative situation. Test anxiety is a type of trait anxiety (Spielberger, Anton, & Bedell, 1976). Spielberger generated the Test Anxiety Inventory (Spielberger, Gonzalez, Taylor, Algaze, & Anton, 1978; Spielberger, 1980). Highly anxious people experience increased state anxiety in the testing atmosphere. This elevated state anxiety level activates worry, and as a consequence, error tendencies. Therefore, according to this theory, both worry and emotionality effect achievement.

Tobias (1979, 1985, 1992) describes two models, one original and one revised, that indicate where anxiety can affect learning at various stages of the learning process. In the original model (1979), the stages are defined as preprocessing, processing, and post processing. Preprocessing is the stage between input (teaching, reading, etc.) and internalizing of information, or encoding. At this stage, anxiety interferes with the input, attention is divided between task and negative self concepts about the task during instruction.

This interference is thought to be cumulative in that if information is not encoded, greater difficulties would occur with future processing. Processing is the stage where input is stored, organized, and related to previously learned knowledge. Anxiety is thought to interfere at this stage by reducing the efficacy of the storage and organization by affecting the cognitive operations required for this task. Finally, post processing is the performance or outcome stage. Anxiety interferes here by reducing the ability to remember previously processed knowledge. These ideas can be seen in Cameron’s (1947) definition of a chronically anxious person: "The
chronically anxious patient usually states that he cannot think clearly, concentrate, or remember as he once could..."

Tobias later revised his original model, which was "...reconceptualized in terms of the cognitive processes influenced by anxiety, rather than the more ambiguous stages described previously." (1992). First, Tobias replaces the preprocessing stage with an encoding stage. He states: "As mentioned previously, this may be a cumulative effect since inadequately encoded material, cannot be processed effectively, nor can it be transferred to long term memory."

Tobias also includes a "memory" component in this revised model. There is a continual transfer of input between these memory and processing levels. This occurs during learning. There is direct interference by anxiety on this transfer. This affects working memory as well as short term and long term memories, which explains the indirect impact (as opposed to the previous direct impact) on the outcome stage.

This theory contributes to what Hembree called the deficits model in two ways. First, anxiety interferes with study and processing of knowledge. Poor preparation and lack of knowledge lead to test anxiety (Culler & Holahan, 1980; Dunn, 1964; Zschintzsch, Groffmann, & Kornfeld, 1978) and poor performance as well as the direct interference of anxiety on outcome measures. Second, remembering poor performance of the past contributes to further anxiety. Covington (1985) describes a similar cycle and states "The impact of stressful anticipation on test performance was shown to depend on student preparedness."
Schwarzer and Jerusalem’s (1992) Process Model of Cognitive Stress

Appraisals is a good summary of the points raised thus far regarding test anxiety.

Three cognitive appraisals are involved at varying degrees at different levels. These cognitive appraisals are Challenge, Threat, and Loss. Challenge occurs when there is a chance to prove oneself or to personally grow. Threat happens when a person perceives danger or anticipates future harm. Loss is when damage (loss of value, self worth, or social standing) has occurred. Four stages are involved, dependent on the number of failure experiences. Stage 1 is the Challenge stage. Although an individual has experienced one to a few failures, confidence remains because he/she is able to cope. Stage 2 is the First Threat. Here, failures increased to a point where threat is greater than challenge and anxiety dominates as the prime emotion. This anxiety is facilitating as some confidence remains and the individual persists with the task. Stage 3 is the Second Threat. There is total uncertainty of outcome, and debilitating anxiety occurs because some self doubt begins to distract the individual from task with worry about performance, ability, and future failures. Finally, Stage 4 is called Loss of Control. Threat is replaced by loss of control, feelings of helplessness, and certainty of future failure.

Science Anxiety

Science Anxiety has been an impediment to science education, probably dating back to the advent of "modern technology." Before that time, science was not feared, and was even revered as something everyone wanted to learn (Hanshaw, 1982). Science changed how people looked at the world - that "truths" built on one another.
Science was thought of as a "treasure" saving lives and illuminating knowledge of the world. Anyone curious enough could learn. By the end of the nineteenth century, this amicable image of science began to change. As Mallow (1981) describes:

Science had become more established as an intellectual enterprise worthy of lifetime study for those who chose it as a career - but more and more distant from those who did not...scientists were not so eager to share their new ideas with the public...Consciously or not, they jealously guarded their status by making science mysterious to nonscientists. (p. 32)

This was the beginning of science anxiety. But what is science anxiety? Chiarello and Czerniak (1987), interpreting theories of Mallow (1981) define science anxiety as the fear or avoidance of science, scientists, and anything science-related. This aversion could cause problems in learning science.

Their concern over science anxiety led to the study of its effects on achievement in elementary school students. They developed one of the only known instruments which evaluates science anxiety - the Czerniak Assessment of Science Anxiety (CASA; Czerniak & Chiarello, 1984).

Mallow (1981) provides further understanding of science anxiety by enumerating several indicators of science anxiety. These include:

- the feeling of inability to comprehend science as evidenced by students limited questioning of teachers in science classes
- panicking on exams and memorizing rather than learning the material
- stereotypes of scientists as evil, frightening, weird, uncreative, boring
- camaraderie in the feeling of ignorance, that everyone else is also science anxious
Science anxiety, as with anxiety in general and test anxiety, is a complex concept. It is influenced by many factors such as negative self concept, negative attitudes toward science, inadequate learning skills, and test anxiety. Negative self concepts or thoughts about one’s inadequacies, can have many sources: parents, teachers/schools, peers, the media, and society in general (Mallow, 1981; Anderson & Clawson, 1992). Parents can cause undue pressure by making comments to children like "You can do anything if you work hard enough" or "I'd really like you to become a doctor". They may perpetuate the anxiety as if it were almost hereditary: "I was never any good at science, so it is alright if you aren't". Recall the indicator of camaraderie presented by Mallow. Teachers and counselors often knowingly or unknowingly add to anxiety. They may classify science as a "male" field, deterring females (Kelly, 1978; Mallow, 1981; Wells, 1985). Science anxiety, as with test anxiety, has been shown to be greater for females than males (Anderson & Clawson, 1992).

Teacher attitude is another aspect effecting science anxiety in students. They may believe that the course is easy or they may present themselves as "intellectually elite" presenting the message "As hard as you try, you will never be as smart as I am. This material is simply too hard for you." Here, student self image is effected. Those who can’t understand the material may feel inadequate, that they don’t have the intelligence to understand science. Science teachers may also be science anxious themselves.
Gabel (1981) studied the concept of course of study and attitude toward science. She found that science majors had better attitudes toward science, and non-science majors had poorer attitudes toward science. This last finding was particularly true for elementary education majors.

Finally, the media and society in general can contribute to negative self concepts in students. Mallow (1981) states "Science anxiety carries over into society at large. Antiscience attitudes are quite the fashion. Writers, artists, teachers of humanities boast of their ignorance of all things scientific." Newscasts often report sensationalistic findings and do not explain the entire results. Conflicting results are portrayed as confusing and not a natural part of discovery. And what of reporter science anxiety? Mallow describes this concept:

Reports of scientific events on the evening news always evoke a science-anxious response in newscasters. After a report of the latest pictures of Saturn, or the latest breakthrough in biological research, you can usually count on one of the newscasters to say with a giggle "You understand that? Not me!" We learn to accept these nervous jokes about the incomprehensibility of science. We learn not to learn science. (p. 4)

Another factor that influences science anxiety is negative attitudes toward science. The concept of science attitudes is again a complex one. Attitude in general has been defined as the evaluative factor of behavioral intention and "is the person’s positive/negative affect towards the behavior in question" (Norwich & Duncan, 1990). Germann (1988) attempts to clarify the concept by dividing science attitude into two parts, that of attitude toward science and scientific attitude. Scientific attitude "refers
to a particular approach a person assumes for solving problems, for assessing ideas
and information, and for making decisions", similar if not identical to the scientific
method (Gauld, 1982). Munby (1983) described scientific attitude as "thinking as
scientists do...acting on evidence in a disciplined way." Attitudes toward science,
simply put, according to Oliver and Simpson (1988) are operationally defined as how
much an individual likes science. Attitudes toward science may also incorporate
scientific attitudes and beliefs such as importance, relevance, or necessity, about the
scientific processes, technology and its products, how science is taught, science
activities, and careers in science. (Germaan, 1988)

Schibeci, in his research review (1986) was interested in three areas which
may influence attitude toward science: popular culture's portrayal of science and
scientists, community attitudes toward science and scientist, and student perception of
scientists. He summarized that generally, scientists in popular culture, as
characterized by such forms as comics, novels, and the mass media, are not seen as
positive figures. The community attitude was "best described as ambivalent." The
positive aspects of science were appreciated, but doubts concerning negative outcomes
of scientific research still existed.

Inadequate learning skills is yet another factor that influences science anxiety.
Mallow (1981,1991; Mallow & Greenburg, 1983) consider the skills for learning
science as different from those necessary to learn other subjects and that the "apparent
difficulty" of these skills and inadequate mastery has convinced many that science is
"beyond the abilities of the average person, or even the well-educated." Reading
scientific material is one skill Mallow advocates as needing attention. Students cannot read science texts or articles as they would in other courses. Instead, he promotes the practice of reading the item many times, taking notes, and thinking over each new idea as it comes. Text readings, if assigned, should be read at least three times: before, during, and after the lecture covers the material.

Other skills that seem to be lacking are science study skills. In her article, Ryan (1989) discusses several of these skills including easier ways to learn vocabulary, how to study illustrations with "two-fingered reading", problem solving, and note taking. Brown and Cranson (1989) discuss how curriculum revisions were planned at Michigan's Lansing Community College which stress learning critical thinking and science process skills, two other areas which need attention.

Finally, one last factor that has a large impact on science anxiety is that of test anxiety. As noted previously, test anxiety and its effect on student esteem and ultimately, student achievement is a major concern in the educational setting. Test anxiety in the science course is no different.

Everson, Tobias, Hartman, and Gourgey (1991) studied what they termed "traditionally difficult academic subject matter, such as that found in mathematics and the natural sciences." They hypothesized that high anxiety would contribute to poor performance. They randomly assigned 214 college students into subject matter groups. The results of their study indicated that the highest level of test anxiety was evoked by science, thus correlating test anxiety and science.
In fact, science courses have been shown to cause more anxiety than many other subjects. Tobias, Everson, Hartman, and Gourgey (1991) studied a sample of college freshmen and reported that they experienced more anxiety about learning science, than they did for learning mathematics, English, or social studies in that order. Another way to examine this connection would be to hypothesize that science anxiety is often triggered by the science test. One view of science test anxiety is treated in a study by Zoller and Ben-Chiam (1988). They looked at test type and its affects on science test anxiety. Students were given a list of nine exam types and were asked their preference. Then they were asked questions concerning the reasons for their choice such as what discipline they had in mind, what effect the exam had on their final grade, and the types of exams they had experienced.

There were two preferred exam types. The first was the “take home exam” where students could use any material and took the exam out of class. The second type was the written “in class exam” where, again, students could use any material, and where time was unlimited. The “classical” exam type, or the in-class written exam where time was limited and no materials could be used ranked seventh out of the nine types. Oral exams either in groups of 2-3 or in class forum style ranked 8th and 9th. Thus one of the most frequently used exam type ranked near the lowest and was one of the most likely candidates for causing stress and test anxiety increases and achievement decreases.
Students saw exams as a “learning device” where the emphasis was “on understanding and thoroughness” rather than on “knowing and remembering” or “superficial rote learning and memorization.”

The authors stated that teachers need to reconsider tests and their objectives. They state evaluation in school needed to be changed in order to reflect those objectives, that tests should be used to evaluate not only students’ learning and development, but also to evaluate courses. If test anxiety was interfering with accurate evaluation of that learning, courses and student evaluation should be changed. In order to improve academic achievement, which is the assumed goal, these authors are saying that teachers should give the preferred test type, especially in science courses, thus alleviating some or all of the test anxiety and thus improving achievement.

Summary

There is no question that the concept of science anxiety is highly elaborate and tangled. This chapter has illustrated several similarities which exist and overlap between theories and models of anxiety, test anxiety, and science anxiety such as worry and lack of confidence in ability. As will be seen in the next chapter, the measurement of the extrapolated concepts which relate to science anxiety as well as the variables studied concerning them, also overlap. What is needed now is further research into the factors involved in science anxiety. How do the variables contribute to science anxiety? What is the extent of their contribution? The variables discussed in the next section have been taken separately, or in relation to test anxiety or science
anxiety, but there has been no attempt to explore them together. As reform movements are indicating a need to refine science education, for example, the evaluation aspects utilizing such examples as authentic assessment as a new method, it would behoove researchers to study how test anxiety, its components, and variables related to it influence science anxiety and its influencing variables in order to further justify such reforms. This research will also add to the understanding of science anxiety in hopes to alleviate or eradicate it in the future.

Statement of the Problem

One ultimate goal concerning science anxiety is to understand it. However, as mentioned before, research relating to science anxiety has had a limited base, focusing on its effect on achievement, on attitude, and on further pursuit of science. Perhaps an alternative focus is needed in addition to work currently in progress and that done in the past. If the existence of science anxiety is known to be detrimental at various levels, it should be studied with the intent to learn what influences it and to what extent. This could change how educators deal with a known problem, for example, achievement scores in science. If these factors are known, reforms could be made in science education and science teacher education so that these factors are taken into account and dealt with via curriculum reform, classroom environment, classroom practice, and the like.

For example, if attitude toward science turns out to have a major influence on science anxiety such that a positive attitude correlates to low science anxiety, educators could make changes in science curricula to improve attitude toward science.
Perhaps this influence is cyclical, and an improved attitude reduces science anxiety and a reduced science anxiety further improves attitude. This should be one cycle educators would like to see continue.

The problem lies in one fact this chapter has illustrated. One could say many variables influence science anxiety, many of which may influence each other. Practically speaking, teachers cannot tackle all these variables in any classroom or curriculum modification. Variables must be narrowed down to identify those having significant influence and those that can be manipulated.

As with the classroom, research, too, cannot address all the variables at once. Thus, the nature of this research will be exploratory, with the purpose being to begin the process of narrowing down variables. Some variables have been researched with respect to so many aspects of science anxiety, they seemed necessary to include. Gender, attitude toward science, and achievement fall into this category. Other variables either have not been researched much in direct relation to science anxiety, such as test anxiety and its components, and parental background, or research has not been done much at all with respect to science anxiety, such as course of study. These variables, then, are of interest in this research.

Definition of Terms

Achievement - level of understanding, skill, or accomplishment, measured by a grade received and indicated in this study by overall grade point average in general (GPA), and science grade point average specifically (SGPA)
Anxiety - a subjective feeling of tension, apprehension, and worry, set off by a particular combination of cognitive, emotional, physiological, and behavioral cues (Brennar, 1985, p. 65)

Attitude - evaluative factor of behavioral intention and an individual’s positive or negative affect toward that behavior (Norwich & Duncan, 1990)

Attitude toward science (SCIA) - how much an individual likes science; belief system incorporating ideas about relevance, importance, necessity of science, technology and its products, and science education (Oliver & Simpson, 1988; Germann, 1988)

Audience anxiety - anxiety caused when one must appear as a speaker in front of classmates and teacher (Paivio, 1965)

Autonomic reactions - sense of nervousness, tension, and bodily symptoms including rapid heart beat, sweating, and nausea (Schwarzer, van der Ploeg, & Spielberger 1982; Schwarzer & Quast 1985; Salamé, 1984)

College students - students enrolled in an institution of higher education

Debilitating test anxiety - test anxiety which hinders performance

Emotionality (TAIE) - component of test anxiety related to the autonomic reactions which tend to occur under examination stress (Liebert & Morris, 1967)

Facilitating test anxiety - test anxiety which increases performance levels

Father education (DADED) - indicates the level of education the father has achieved

Father with science occupation (DADSCI) - indicates a father whose occupation relates to or requires the use of any science
Gender (GEN) - whether a student is male or female

Major (MAJ) - a field of study in which a student, especially at the college level, specializes

More Science (MORESCI) - whether or not a student will take more science courses

Mother education (MOMED) - indicates the level of education the mother has achieved

Mother with science occupation (MOMSCI) - indicates a mother whose occupation relates to or requires the use of any science

Non-science major - any student not studying any of the life or physical sciences as a course of study at the college level

Optional science courses (OPT) - future courses to be taken of the elective type (freedom of choice is inferred)

Optional total (OPTTOT) - sum of all courses and prerequisites a student took of the elective type

Required science courses (REQ) - future courses to be taken of the required type

Required total (REQTOT) - sum of all courses and prerequisites a student took of the required type

Science anxiety (SAI) - a fear or aversion toward science concepts, scientists, and science related activities (Chiarelott & Czerniak, 1987, p. 202)

Science major - any student studying any of the life or physical sciences as a course of study at the college level
Scientific attitude - a particular approach a person assumes for solving problems, for assessing ideas and information, and for making decisions

(Germann, 1988, p. 690)

Self concepts - thoughts about one’s abilities

Self esteem - respect for oneself

State anxiety - transitory condition characterized by subjective feeling of tension, apprehension, increased physiological symptoms which fluctuate over time

(Spielberger, Gorsuch, and Lushene, 1970, p. 2)

Stress - variation in environmental characteristics by degree of objective danger (stimulus) (Gaudry & Spielberger, 1971, p. 66)

Test anxiety - feelings of apprehension and worry cognitions in academic environments where the performance of students is under scrutiny

(Salamé, 1984)

Test irrelevant thinking - loss of attention to task during situations of performance evaluation (Wine, 1971)

Threat - subjective interpretation of a situation as dangerous (perception)

(Gaudry & Spielberger, 1971, p. 66)

Trait anxiety - stable differences in anxiety proneness or tendency to respond to situations thought of as threatening (Spielberger, Gorsuch, and Lushene, 1970, p. 2)

Worry (TAIW) - component of test anxiety related to any cognitive expression of concern about one’s own performance (Liebert & Morris, 1967, p. 975)
Research Statements

In order to better understand science anxiety, certain variables will be explored. The following research statements will be investigated to find those particular variables of the entire group that best explain or affect science anxiety:

1) Correlations between science anxiety and each of the variable groups - gender, course of study, parent background, achievement, test anxiety components worry and emotionality, and attitude toward science will be calculated to determine the extent of the relationships between those variables and science anxiety.

1a) Will there be significant correlations between science anxiety and gender (GEN)?

1b) Will there be significant correlations between science anxiety and course of study variables of MAJ, MORESCI, REQ, OPT, REQTOT, and OPTTOT?

1c) Will there be significant correlations between science anxiety and parent background variables of DADSCI, MOMSCI, DADED, and MOMED?

1d) Will there be a significant correlation between science anxiety and achievement (GPA, SGPA)?

1e) Will there be significant correlations between science anxiety and the test anxiety components worry and emotionality (TAIW, TAIE)?
1f) Will there be a significant correlation between science anxiety and attitude toward science (SCIA)?

2) Regression models will be developed to describe the relationships among all variables, and to determine the combination of variables that best predicts science anxiety. This will be done using multiple linear regression analyses.

Delimitations

1. This research dealt only with the variables of worry, emotionality, gender, course of study, parent background, achievement, and attitude toward science. Other influencing factors of science anxiety reported in this chapter (e.g., parent attitude, teachers, peers, media, class environment, inadequate study skills, and test type) will be left for later research.

Limitations

1. The sample was one of convenience and the results may not be generalizable past those included.

2. Only a subsample could be used to study achievement because only those students who gave permission to release their records could be used in this sample. The volunteers for this group were primarily science majors.

3. The sample size of the subsample is small compared to the number of variables studied.
CHAPTER 2

LITERATURE REVIEW

Introduction

This chapter presents a review of the literature that pertains to research concerned with science anxiety and related variables. The summary is an illustration of the complexity and ambiguity of the concepts anxiety, test anxiety, and science anxiety. This chapter is divided into two sections. The first section of the literature review includes a discussion regarding the development of measurement tools used to evaluate general anxiety as well as test and science anxieties. Table 1 lists the instruments to be discussed along with their abbreviations. The second section is a synopsis of literature that deals with research variables that were studied. These include test anxiety and its subcomponents worry and emotionality, gender, course of study, parent background, achievement, and attitude toward science.
Table 1

**Abbreviations of Instruments**

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td>AAT</td>
<td>Achievement Anxiety Test</td>
</tr>
<tr>
<td>CASA</td>
<td>Czerniak Assessment of Science Anxiety</td>
</tr>
<tr>
<td>MAS</td>
<td>Manifest Anxiety Scale</td>
</tr>
<tr>
<td>RTT</td>
<td>Reaction to Tests</td>
</tr>
<tr>
<td>STAI</td>
<td>State-Trait Anxiety Inventory</td>
</tr>
<tr>
<td>TAI</td>
<td>Test Anxiety Inventory</td>
</tr>
<tr>
<td>TAQ</td>
<td>Test Anxiety Questionnaire</td>
</tr>
<tr>
<td>TAS</td>
<td>Test Anxiety Scale</td>
</tr>
<tr>
<td>TASC</td>
<td>Test Anxiety Scale for Children</td>
</tr>
<tr>
<td>TPQ</td>
<td>Test Procrastination Questionnaire</td>
</tr>
<tr>
<td>WEQ</td>
<td>Worry-Emotionality Questionnaire</td>
</tr>
</tbody>
</table>
Research

Measurement - Anxiety

The development of one of the first instruments designed to evaluate anxiety is described in a study inspired by Hull and Spence's studies. This is Taylor's work on an instrument to measure the presence of anxiety (1951, 1953). She used their theory to develop the Manifest Anxiety Scale (MAS). The MAS is a measure of drive/anxiety or the predisposition to experience anxiety. The scale consists of fifty statements to which a subject responds as being true or false about himself/herself. Statements were developed by asking psychologists to designate those items from the Minnesota Multiphasic Personality Inventory which were considered to exhibit anxiety. Here, anxiety was defined by Cameron's (1947) description of the chronically anxious. The anxious patient may be characterized by symptoms of two types. The first type includes tension - muscular, with aching neck, shoulders, back and limbs, and muscle twitches; loss of appetite or its opposite - constant hunger; cardiac irregularities; difficulty breathing; and cold extremities. Symptoms of the second type are less physical and more mental. These include concentration and memory lapses, difficulties with keeping to task, lack of motivation, worry, fatigue, irritability, and discouragement. Both types reflect the components of test anxiety discussed in Chapter one. The first type is comparable to emotionality, the second to worry.

Examples of chosen statements include "I blush easily", "I always have enough energy when faced with difficulty", and "I frequently find myself worrying about something." The final score is established from the number of items which
indicate the presence of anxiety. This score identifies whether or not anxiety is a personality trait of the subject.

Reliability of this instrument was determined by the author and corroborated by the following studies. Taylor found that retesting results of 59 students after three weeks provided a Pearson product-moment coefficient of 0.89. Hedlund, Farber, and Bechtoldt (Unpublished) obtained a test-retest coefficient of 0.82 after 5 months and 0.81 for the 9-17 month period. Newton, Kameoka, Hoelter, and Tanaka-Matsumi (1984) concur with reliabilities of 0.84 and 0.86 (Cronbach's alpha and Tucker Lewis Reliability Coefficient respectively).

Validity was determined by Taylor. She submitted the scale to 15 judges who were told to sort the items into four piles according to comprehensibility. Twenty-eight items were selected and revised. These revised items were given to 18 new judges who ranked them on comprehensibility and faithfulness in meaning to the original items. Both instruments, original and revised, were given to 59 introductory psychology students. The Pearson product-moment correlation of 0.85 was obtained. Other studies since Taylor's have further reinforced the validity. Two found high correlations between the MAS and other scales of anxiety, personality, and depression (Bull & Strongman, 1971; Meites, Lovallo, & Pishkin, 1980).

Another instrument widely used to evaluate anxiety was the State-Trait Anxiety Inventory (STAI). Spielberger and associates Gorsuch and Lushene (1970) developed the STAI from the State/Trait theory of anxiety discussed previously (Spielberger, 1966). This instrument measures state and trait anxieties separately. The state scale
includes twenty statements to which the subject responds with a choice from a four point scale (not at all, somewhat, moderately so, very much so). The subject response is determined by how he/she feels at that moment. Statements include "I feel calm", "I feel upset", and "I feel over-excited and rattled." The trait scale utilizes another four point scale (almost never, sometimes, often, almost always) which subjects use to rate twenty statements as to their feelings in general. Items include "I am a steady person", "I take disappointments so keenly that I can't put them out of my mind", and "I feel pleasant."

Reliability studies have shown fairly consistent results. Test/Retest reliability scores have ranges of 0.73-0.86 (DeWine & Pearson, 1985) and 0.65-0.88 (Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983) for the total instrument. The Trait portion has been tested to have Test/Retest reliabilities of 0.76 (Spielberger, Gorsuch, and Lushene, 1970), 0.65-0.86 (Spielberger et al., 1983), and 0.78-0.86 (Fuqua & Newman, 1989). The State portion resulted in Test/Retest reliability of 0.27 (Spielberger, Gorsuch, and Lushene, 1970) and 0.16-0.50 (Fuqua & Newman, 1989). The lower reliability of the State portion is explained by the transitory nature of state anxiety. Another test of reliability is internal consistency. Hutchinson (1992) reported the internal consistency to be r=0.86-0.95 for State. Spielberger et al. (1983) found the internal consistency of the Trait portion to be r = 0.89-0.91.

Several studies were done to demonstrate the validity of the STAI. Donham, Ludenia, Sands, and Holzer (1984) cross validated findings in two of their earlier investigations, one in 1980, the other in 1981. They had administered the STAI as a
pre-test and post-test as part of an alcohol rehabilitation program. Comparisons were made between the 1980 sample and the 1981 sample examining pre- and post-test scores for both State and Trait anxieties (2X4 comparison). The pre-test and post-test scores for the State portion, and the pre-test scores for the Trait portion did not significantly differ for the two samples. There was a significant difference between samples, however, on the State post-test. The authors state the stability, or non-significant differences between samples (with the one example), across time determines construct validity with State and Trait anxieties being the construct. They also conclude that the STAI is useful in evaluating anxiety in the alcoholic population. Brown and Duren (1988) showed that exploratory factor analysis supports the STAI as a measure of separated state and trait dimensions in assessing the Black community. Hutchinson (1992) demonstrated concurrent validity by correlating the STAI with the Beck Depression Inventory and the Tennessee Self Concept Scale. Validities were determined for the separate scales as well. Spielberger et al. (1983) correlated the STAI with "other published measures" and the results were 0.75-0.80 for the Trait scale and 0.65-0.69 for the State scale. DeVito (1984), studied state anxiety before, during, and after an anxiety-producing (exam-stress) and during a non-threatening (exam-relaxed) experience. Anxiety in the latter situation was significantly lower than for the stress situation. DeVito states that these results add to the validity of the state scale as a measure of elevations in state anxiety. Concurrent validity of the Trait scale was evidenced by the correlations of 0.75 with the IPAT (Institute for Personality and Ability Testing) Anxiety Scale, 0.90 with the MAS, and 0.53 with the Affective
Adjective Checklist, all of which claim to be measures of trait anxiety (DeWine & Pearson, 1985).

**Measurement - Test Anxiety**

If there was a hierarchy concerning the development of instruments designed to evaluate test anxiety, Mandler and Sarason's (1952) Test Anxiety Questionnaire (TAQ) a "questionnaire on attitudes toward test situations" would be at the top as it is perhaps the first, and also the predecessor of many to follow. This instrument contains 67 questions, 42 involving anxiety and 25 involving attitude. One hundred and fifty-four Yale College students in an introductory psychology course were given the TAQ. On the basis of the results, the students were then divided into two groups, high anxiety (HA) and low anxiety (LA). These two groups were further divided into three groups each, success, failure, and neutral. All groups took three intelligence tests. The success groups were told that they performed well, the failure groups were told that they had done worse than predicted from aptitude scores, and the neutral groups were told nothing as to their performance. Mandler and Sarason concluded that the intervening success or failure report improved performance for the LA group but lowered performance for the HA group. They stated that for HA subjects, any reference to the tests evoked task irrelevant responses, so their performance would decrease. The LA subjects reacted to the success or failure reports by increasing their task relevant responses, which in turn, helped improve their scores.

Mandler and Sarason (1952) reported the reliabilities of the TAQ to be 0.99 (Split/Half) and 0.82 (Test/Retest - six weeks). These numbers are corroborated by

39
Tryon (1980) with a Split/Half coefficient of 0.91 and Test/Retest coefficient of 0.82. Test/Retest coefficients of >0.80 were reported by Schmitt and Crocker (1982). These authors also reported internal consistencies of 0.58-0.87 (KR-20).

The first validity established for this instrument was done by Mandler and Sarason (1952). Concurrent validity was determined by correlating the TAQ with other behavioral ratings of anxiety symptoms (such as perspiration, inappropriate questioning and laughing, and restlessness). The result of this correlation was a point biserial correlation (phi) of 0.59 and significance at the p < 0.001 level.

The next level of the test anxiety scale hierarchy would include two major instruments that were derived from the TAQ. These would be the Test Anxiety Scale (TAS) (Sarason, 1958) and the Worry/Emotionality Questionnaire (WEQ) (Liebert & Morris, 1967). The TAS originally had 21 items from the TAQ rewritten into a true/false format. According to Sarason (1978), through factor analyses and item analyses, the TAS has undergone transformations resulting in the addition of 16 new items to produce the now-used 37 item scale. The added 16 items increased reliability and sensitivity (Sarason, 1972). Reliability was reported by Sarason (1978) as Test/Retest coefficients of 0.80-0.87.

Validity was documented by correlations with other related scales. Spielberger, Gonzalez, Taylor, Algaze, and Anton (1978) reported the correlations of 0.51-0.55 with STAI-Trait and 0.39-0.56 with the STAI-State scale. They determined a negative relationship with Grade Point Average as well (-0.29- -0.39). Deffenbacher and Deitz (1978) assessed external validity by studying the attention theory proposed by the
scale. That is, in a class exam environment, an increase of anxiety beyond that which is facilitating will be more interfering, thus deferring attention away from the task. The authors administered the TAS to sophomore psychology students in the fourth week of the semester. Class exams were given in the 6th, 11th, and 16th weeks. Normal exams were exams given as usual with typical instructions for a multiple choice exam. Relaxed exams were given with relaxation instructions prior to taking them. Stress related to evaluation elicited more worry and emotionality in the highly anxious regardless of test type. The authors state this increase could have interfered with the performance. Relaxation had little effect in decreasing stress in HA students. Performance was therefore, also not effected. HA students performed less well than LA students, again, regardless of test type. The authors conclude "Thus, the study successfully extends laboratory findings to naturalistic settings, thereby supplying further evidence for the external validity of the TAS" (p. 449). In other words, since this instrument successfully measured test anxiety in more than one situation type (classroom and experimental settings), external validity, validity outside the experimental setting, is seen.

The WEQ is another instrument derived from the TAQ. Liebert and Morris (1967) selected the items "on the basis of independent judging by the authors" which reflected either autonomic (emotionality) or cognitive (worry) symptoms. Five Worry and 5 Emotionality items were used. The response format was a 5-point scale from "the statement does not describe my feelings" to "the feeling is very strong."
Test/Retest reliability ranges reported are 0.76-0.83 for Emotionality and 0.68-0.69 for Worry (Liebert & Morris, 1967; Tryon, 1980).

The last level of the hierarchy consists of the instruments derived from the TAS - the Test Anxiety Scale for Children and the Test Anxiety Inventory. Sarason and colleagues (Sarason, Davidson, Lighthall, Waite, & Ruebush, 1960) produced the Test Anxiety Scale for Children (TASC) which measures the anxiety for children in test or test-like situations. The instrument includes 30 questions which require a yes or no response. A yes response indicates the admission of an unpleasant experience. A high score is indicative of a “test anxious” subject, or anxious behavior in a variety of situations. A low score indicates the subject does not demonstrate test anxiety characteristics. Sarason et al. (1960) determined the reliability of the instrument by way of a split half coefficient of 0.88. This value agrees with that found by Ludlow and Guida (1991) where their reliability coefficient was an alpha of 0.89.

Sarason et al. (1960) determined validity by correlations of the TASC to 1) teacher rating of anxiety, 2) IQ scores, and 3) achievement scores. They administered the TASC to 2211 students in grades 2-5. The scores correlated to teacher ratings overall with a coefficient of 0.20. Correlations to IQ and achievement were negative (-0.012- -0.284 and -0.002- -0.294 respectively), and increased with age. These findings meant, the authors state, test anxiety has an interfering effect, especially on achievement. Apparently, this effect has increasing influence as children progress through their academic career. Those with low test anxiety perform better and tend to have higher IQ scores. Test anxiety interferes with performance according to the
correlation that shows those students with high test anxiety tend to have low levels of achievement and are more likely to have lower IQ levels. Feld and Lewis (1967) performed a factor analysis by gender, one for males and one for females, on the TASC with the responses of 7551 2nd grade students. They found four factors: test anxiety, somatic signs of anxiety, poor self-evaluation, and remote school concern. Test anxiety accounted for the greatest variance for both sexes. These results add to the validity of the TASC.

Finally, the other branch from the TAS is the other instrument derived from it - the Test Anxiety Inventory (TAI). The authors gave the 37 item TAS to 426 psychology students. Eleven items were discarded due to low point-biserial correlation between responses of each item and total score. These 11 seemed more related to study habits than to test anxiety. Simplification and addition of items with content validity was the next step in the scale's construction. Next, the response format was changed from true/false to a four point scale consisting of the choices “almost never”, “sometimes”, “often”, and “almost always.” This new 32-item instrument was administered to 300 psychology students and the item-remainder correlations were calculated for each item. Ten questions were discarded due to low correlations. Subscales were developed based upon high loadings on the worry and emotionality factors using factor analysis. Twenty items were given to another sample of 389 students, were factor analyzed again, and high loading items on the worry and emotionality factors were again chosen. The final instrument contained eight items in each subscale with four additional items included in the total scale. The reliability for
the entire instrument was determined to be 0.94-0.95 and for the subscales to be 0.88-0.90 (worry) and 0.90-0.91 (emotionality). These numbers are consistent with later studies. Spielberger (1980) reported reliability coefficients of 0.94-0.95. Others range from 0.80-0.96 (McAuliffe & Trueblood, 1986).

Spielberger et al. (1978) determined concurrent validity by correlating the TAI to the TAS and the STAI. Correlation coefficients were 0.82-0.83 (total) and 0.69-0.79 (worry and emotionality subscales) between the TAI and the TAS, and 0.34-0.67 (total) and 0.28-0.67 (worry and emotionality subscales) between the TAI and the STAI. It seems as though the validity was better between the TAI and TAS. Perhaps the TAI is more similar to the TAS than to the STAI where the correlations were not very high overall.

One last instrument should be discussed as it is another widely used scale. Alpert and Haber (1960) studied test anxiety and its effect on achievement. They developed a measure, called the Achievement Anxiety Test (AAT), to indicate the presence of two types of test anxiety in subjects: facilitating and debilitating test anxiety. Facilitating anxiety is that type of anxiety which increases performance levels, and debilitating anxiety is that which hinders performance. The AAT identifies those subjects who are “facilitated” or “debilitated” by test anxiety. It has two parts, a nine item “facilitating” scale and a ten item “debilitating” scale, both scored on a five point range. An example of an item on the “facilitating” scale is “I work most effectively under pressure, as when the task is very important.” An example of an
item on the "debilitating" scale is "In a course where I have been doing poorly, my fear of a bad grade cuts down my efficiency."

Alpert and Haber (1960) report the Test/Retest reliability to be 0.87 for the facilitating subscale and 0.83 for the debilitating subscale. Griffore (1977), concentrating on the debilitating scale only, found Test/Retest coefficients of 0.87 for 10 weeks and 0.76 for 8 months.

Many studies have used the AAT and thus have added to its validity. Griffore (1977) demonstrated a correlation between AAT debilitating scale and the TAS to be 0.64. Tryon (1980) cites correlations with the TAQ: 0.64 (debilitating) and -0.40 (facilitating). TAQ correlates negatively with the facilitating scale thus those with high facilitating anxiety tend to have lower test anxiety while those with low facilitating anxiety tend to have greater levels of test anxiety. The two subscales correlated with each other by -0.37. Those with high levels of facilitating anxiety have low debilitating anxiety, and those with low levels of facilitating anxiety have high levels of debilitating anxiety. This makes sense theoretically, if one thinks of stages of test anxiety described by Alpert and Haber (1960). Test anxiety consists of facilitating anxiety first, and debilitating anxiety is low. When test anxiety changes at the level where debilitating anxiety increases, facilitating anxiety decreases.

Plake, Smith, and Damsteegt (1981) discussed predictive validity in their study of the relationship between AAT with the STAI and with achievement on mathematics tests. Results showed correlations -0.24 (facilitating and state), -0.28 (facilitating and trait), 0.38 (debilitating and state), and 0.56 (debilitating and trait). The correlations
with achievement were 0.22 for the facilitating and -0.23 for the debilitating scales. Langham-Johnson (1981) also indicated predictive validity with achievement. She adds that the AAT may be useful as a retest measure because there were no significant "learning effects" when the AAT was used for both pre and post testing in her study.

There are two other scales to be discussed. One caution is that because they have not been used to the same extent that the previously described instruments have, reliability and validity studies are unavailable. One particular component of test anxiety has its own measure. Task interference, specifically procrastination, was studied by Rothblum, Solomon, and Murakami (1986) who indicate a relationship between procrastination and test anxiety. This relationship is corroborated in Kalechstein, Hocevar, and Kalechstein (1988). They used the Test Procrastination Questionnaire (TPQ; Kalechstein, 1988) for this study. The TPQ is an instrument that consists of ten self-report items with a four point scale (not at all, only somewhat, quite, and very typical of me) for response.

The second scale, Reaction to Tests (RTT; Sarason, 1984), was employed to measure the four dimensions of test anxiety: tension, worry, test-irrelevant thinking, and bodily symptoms. Significant correlations were found between procrastination and tension, worry, and test-irrelevant thinking. Perhaps, since procrastination is so correlated to test anxiety specifically, it is also tied to other evaluation situations as well. This would include preparations for speeches, approaching a teacher with questions, and writing papers.
Measurement - Science Anxiety

There is very little in the literature that deals with science anxiety, so it is not surprising to find only two instruments designed to assess this specific anxiety type. First, the Czerniak Assessment of Science Anxiety questionnaire (CASA) is described by Czerniak and Chiarelott (1984) as an instrument to "assess students' levels of anxiety toward science and science-related topics." It consists of twelve Likert-type questions which relate to four subtopics: 1) testing situations in the science classroom, 2) laboratory/experiment situations, 3) science classroom/lecture situations, and 4) science-related situations. The response format is a five point scale from "very calm" to "very nervous." The purpose of that study was to determine the effect science anxiety has on science achievement in 4th, 6th, 8th, and 9th graders.

The authors demonstrate content and face validity by having a panel of seven (a teacher of each grade level [4th, 6th, 8th, and 9th] involved, and three professors of education) examine the instrument. The panel was asked to comment on any difficulties or problems with the instrument. Several changes were made after the comments were read, and the final forty-eight item instrument was pilot tested on fifty 5th and 7th grade students.

Reliability was determined by internal consistency. The resulting Cronbach's alphas ranged from 0.93-0.96 depending on grade level and student gender. Wynstra and Cummings (1990) used the CASA in their study of 101 10th and 12th grade chemistry students. Here, they provide reliability and validity of the CASA. They found Test/Retest reliability to be 0.69 after 6 months, and the internal consistency to
be an alpha of 0.93. The authors demonstrate validity by correlating the CASA with achievement, and the TAI. The only significant correlation was with TAI-emotionality (0.25). The authors state "the construct of science anxiety does not significantly improve the prediction of grades in chemistry class." They also conclude that test anxiety and science anxiety may overlap, but the constructs are not equal.

The other measure of science anxiety is the science anxiety instrument used by Mallow in his Science Anxiety Clinic (1981). This instrument consists of 44 items designed to "ascertain...whether the students are specifically anxious about science or whether they have other problems..." The subject is told to indicate that response which best describes them in each situation. The response format is a 5 point Likert-type with the choices being "Not at all", "A little", "A fair amount", "Much", and "Very much." Examples of items include "Converting kilometers to miles", "Planning a well-balanced diet", "Focusing a microscope", and "Memorizing the names of elements in the periodic table." Mallow does not describe this instrument's development, nor does he provide any reliability or validity evidence. There also seem to be no other studies which have used this instrument.

**Variables**

As was seen in Chapter One, the variables associated with science anxiety directly or indirectly, are numerous and interrelated themselves. The variables in this study, therefore, will be restricted to those most researched and/or seemingly most influential. These will be gender, course of study, parent background, achievement,
test anxiety and its subcomponents worry and emotionality, and attitude toward science.

**Gender**

Another variable of interest is gender. Hembree (1988) conducted a meta analysis and summarizes several points concerning gender and test anxiety. He concludes that 1) males consistently showed lower test anxiety levels than females, 2) males showed lower worry and emotionality levels than females, and 3) there is a small gender difference when children are young, there is an increase during grades 5-10, and then a decline thereafter.

Science anxiety, as with test anxiety, has been shown to be greater among females than males (Anderson & Clawson, 1992). Chiarelott and Czerniak (1987) studied 532 fourth, sixth, eighth, and ninth grade students. Each student completed the Czerniak Assessment of Science Anxiety (CASA). Results indicated that females were always more science anxious than males at all grade levels. This compares with Hembree's finding with test anxiety. As stated earlier, Wynstra and Cummings (1990) used the CASA in their study of high school (grades ten through 12) chemistry students. They too found that females scored significantly higher on the CASA than did males.

**Course of Study**

Course of study may be directly related to science anxiety. It may also be indirectly related to science anxiety through attitude toward science. Call to mind Oliver and Simpson's (1988) definition of attitude toward science as being how much
an individual likes, values, and is involved with science. For students, this may be measured by such things as extracurricular science-related activities, positive behavior in science class, choice of major, or by how many science courses a student takes. This last indication (DeBoer, 1984) is of particular interest at higher levels of education such as high school, and especially college where course choice is, for the most part, up to the student. First, total number of courses indicates a level of involvement. Course type also illustrates the focus of the involvement. Students take courses to fulfill requirements, but more interesting are the number and nature of courses they elect to take. These elective courses are those taken out of interest not necessity. A student who has the opportunity to take an elective and who chooses a science course surely has a positive attitude toward science. This student must appreciate and value of science to take a course outside of a requirement.

Parent Background

Parental influence is another variable which can be a powerful motivation toward or against science. Home environment, and more specifically parental involvement, were shown to influence attitudes toward science. Simpson and Oliver (1990) studied 178 science courses in 12 North Carolina schools. They administered an instrument meant to measure attitude toward science to 4500 students in grades 6-10. Attitude toward science correlated with five variables related to family support. Correlations ranged from $r = 0.48$ to $r = 0.54$.

Parent attitude, and thus their level of involvement, may be influenced by their occupation or education level. Remember Mallow's (1981) description of parental
stress with comments such as "You can do anything if you work hard enough" or "I wasn't good at science so you can be bad at it too"? A parent whose occupation is science-related and/or whose level of education is high might make the former statement. They would tend to have a good attitude toward science and would then be more likely to support science education in the home and be more involved. A parent whose occupation is non-science related and/or has a low level of education might make the latter statement. These parents might be more science anxious themselves and feel less qualified to get involved with science at home.

Germann (1994) discusses parent education in his study of factors involved with acquisition of science process skills. He included parent education because he made the assumption that parents with higher levels of education would place a high value on education in general in the home. He found that parent education affected science process skills directly by way of attitude and cognitive development, thus supporting his hypothesis. Schibeci and Riley (1986) used NAEP data acquired from 17-year-olds in a correlational study of 42 NAEP items concerning science achievement and parent education. Their result was a correlation between science achievement of students and parent education of $r = 0.38$.

Assessment of a parent's education level is fairly straightforward. However, occupation assessment may be more complicated and in need of some level of organization or coding scheme. Nam and Powers (1983) developed a guide of occupational and socioeconomic scores. They reviewed literature of status measurement, outlined methods for determining occupational status scores, and gave
examples of how these scores may be used in research. Finally, in the appendix, they offer a variety of occupational scores and types available for many situations in research and give instructions as to how they may be used.

**Attitude Toward Science**

Lastly, there are studies that examined science anxiety and its relationship with attitude toward science. Gabel (1981) studied 156 students in an introductory geology course for non-geology majors. Twenty-four of these were elementary education majors. Her results indicated that science majors have a more positive attitude toward science than non-science majors and that elementary education majors alone were similar to the rest of the non-science majors in their negative attitude toward science. They may feel inadequately prepared to teach the science class, doubting their own ability (Mallow, 1981). These feelings, if noticed by students, can add to their own science anxiety.

**Summary**

It is apparent that many instruments have been developed to measure anxiety and, specifically, test anxiety. These concepts of general anxiety and test anxiety are seen to overlap, and this is clear when looking at the instruments designed to measure them. One example might be the cognitive and physical nature of questions found in both types of instruments such as the MAS for anxiety and the WEQ for test anxiety. What is also apparent is the lack of instruments for science anxiety. Other instruments designed for other age groups, such as college students, are lacking.
The variables involved with science anxiety are not so limited. In fact, their number is staggering. The variables described in this chapter were chosen because 1) they have consistently been included in previous studies, or 2) they are potentially critical variables which have been neglected. Gender would be an example of the first type of variable, and course of study is an example of the second type.

Test anxiety, and specifically the components worry and emotionality, actually fall into both categories. They have often been included as the dependent variable, but infrequently studied as to how they might relate to other anxieties, such as science anxiety. Main points of research include the facts that worry tends to be a greater hindrance to and a better predictor of achievement than emotionality. There seems to be the beginning of a link between test anxiety and science anxiety, but further evidence is needed to better understand this relationship.

Gender is a variable that tends to be included in much research as its influence can be found in many areas. This is also true with the research concerning science anxiety. Test anxiety, worry, emotionality, and finally science anxiety all tend to be higher for females than for males.

Parental background is another example of the second type of variable. It has not been a variable researched much in relationship to science anxiety. Thus, its relationships and possible influence are fuzzy at best. The pattern derived from the literature suggests that parents with higher levels of education and/or occupations related to science value education generally and science education specifically. That value may result in the instilling of those values in their child.
Finally, course of study and attitude toward science may relate to science anxiety. Test anxiety has been show to be greater for science than for many other content areas. As would be expected, science majors tend to have a better attitude toward science. Again, it is assumed that a better attitude toward science will result in a lower degree of science anxiety.

These few variables are so intertwined in the literature, it is difficult to sort out how they interrelate to each other and, ultimately, science anxiety. It is as if only pieces have been examined and not summarily combined. That is the intent of this study - to determine the interrelationships of these variables and science anxiety. Perhaps some are more important than others. Also, due to their complex nature, the fact that so many variables interact, may mean that variables could be considered in groups, almost as if they were one variable. Therefore, not only will each variable be considered, but subsets of variables will be examined to see if there is a pattern to their relationship to science anxiety. Perhaps this will provide more insight as to the nature of science anxiety so that it may be effectively reduced.
CHAPTER 3

METHODS & PROCEDURES

Design

This research was descriptive and correlational in design. Relationships between the dependent variable Science Anxiety, and other response variables including Test Anxiety and its components (Worry and Emotionality), Attitude toward Science, and Achievement along with the independent variables: Gender, Course of Study, and Parent Background were investigated. First, basic descriptive statistics including means and standard deviations were examined to characterize the sample. These were followed by correlational analyses for exploration of the relationships among the independent variables and their relationships with the dependent variable of science anxiety. The models resulting from these analyses were compared to the hypothesized models described later in this chapter. Modifications to the proposed models were made based upon the findings of this study.
Pilot Study

The pilot study was conducted for two main purposes. First, since the data gathering instruments were a compilation of published instruments designed for a variety of age groups, reliability estimates were computed for the age group involved in this study. Second, the data obtained in the pilot was subjected to descriptive and correlational analyses to provide a sense of direction for the analysis of the data from the total sample.

Table 2 lists the variables and instruments used and their abbreviations. These abbreviations are used for the remainder of the study in reference to the variable or instrument they represent. Students indicated whether they were male or female for the gender (GEN) variable. Major (MAJ) refers to the area of study a student was pursuing and was coded as science major or non-science major. MORSCI responses indicated whether or not a student planned on taking more science courses in the future. Students were asked to indicate which courses they would be taking and if those courses would be required (REQ), or if they were to be elective (OPT). Then, the students were asked to indicate on a list those courses they had taken. Again, they were to distinguish which were required and which were elective. Each required course and each elective course and their prerequisites were tallied, and the totals (REQTOT, OPTTOT) were reported. In order to obtain a measure of each student’s past experience and involvement with science, a weighting of the course taken was devised. The weighting was done by determining the number of pre-requisite courses required for each course taken (See Appendix B). For example, Animal Science 310
Table 2

Summary of Abbreviations Used for the Instruments, Predictor Variables, and Science Anxiety

<table>
<thead>
<tr>
<th>Variable or Instrument</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>GEN</td>
</tr>
<tr>
<td>Major</td>
<td>MAJ</td>
</tr>
<tr>
<td>More Science Courses Will be Taken</td>
<td>MORSCI</td>
</tr>
<tr>
<td>More Required Science Courses Will be Taken</td>
<td>REQ</td>
</tr>
<tr>
<td>More Elective Science Courses Will be Taken</td>
<td>OPT</td>
</tr>
<tr>
<td>Total Number of Required Science Courses and Prerequisites Taken</td>
<td>REQTOT</td>
</tr>
<tr>
<td>Total Number of Elective Science Courses and Prerequisites Taken</td>
<td>OPTTOT</td>
</tr>
<tr>
<td>Father's Occupation - Science Related or Non-science Related</td>
<td>DADSCI</td>
</tr>
<tr>
<td>Mother's Occupation - Science Related or Non-science Related</td>
<td>MOMSCI</td>
</tr>
</tbody>
</table>
(table 2 continued)

<table>
<thead>
<tr>
<th>Variable or Instrument</th>
<th>Abbreviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Father's Level of Education</td>
<td>DADED</td>
</tr>
<tr>
<td>Mother's Level of Education</td>
<td>MOMED</td>
</tr>
<tr>
<td>Test Anxiety Inventory - Total</td>
<td>TAI</td>
</tr>
<tr>
<td>Test Anxiety Inventory - Emotionality Component</td>
<td>TAIE</td>
</tr>
<tr>
<td>Test Anxiety Inventory - Worry Component</td>
<td>TAIW</td>
</tr>
<tr>
<td>Attitude Toward Science</td>
<td>SCIA</td>
</tr>
<tr>
<td>Science Anxiety</td>
<td>SAI</td>
</tr>
</tbody>
</table>

has three course pre-requisites, so it was weighted by four (one for the course plus one for each prerequisite). If a student indicated a course as required, four would be added to that student's REQTOT score. A course taken that had a prerequisite list of 7, therefore, meant much more science involvement than a course with a prerequisite list of 0 or 1. The minimum score for a course was 1. The courses and their prerequisites were then totaled for each course type, required (REQTOT) or elective (OPTTOT). Parent occupation - science related or not (DADSCI, MOMSCI), and education level (DADED, MOMED) were the next variables. The last five variables
on Table 2 are the response variables of test anxiety total (TAI), test anxiety, emotionality component (TAIE), test anxiety, worry component (TAIW), attitude toward science (SCIA), and science anxiety (SAI).

The pilot sample consisted of a Summer 1995 Microbiology course laboratory section at a major university. Initially, there was a total of 27 participants. Two were dropped from the analysis due to missing data (N=25). The sample included 44% male and 56% female, with 93% being science majors and 7% being undecided. The undecided were classified as non-science majors for purpose of the analysis.

As stated above, the instruments (to be described in the Instrumentation section) were administered in lab sections, and before instruction had started. Students were told that they would be participating in a study examining their opinions concerning tests in general and about science. They were informed that they would be asked to provide background information such as their gender, major, their parents' education and occupation, and what other courses they had taken or had intended to take at the university. Finally, they were instructed to be as thorough as possible, and that their participation in the study was completely confidential and voluntary.

All data was coded and entered by way of Wylibur and the Statistical Package for the Social Sciences (SPSS, 1990). Table 3 is the summary of the coding scheme used in the analysis.
Table 3

Coding Scheme Used in All Entry of Instrument Data

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code</th>
</tr>
</thead>
</table>
| GEN      | 1 = Male  
          | 2 = Female |
| MAJ      | 1 = Non-science, undecided  
          | 2 = Science |
| MORSCI   | 0 = No more science courses to be taken  
          | 1 = More science courses to be taken |
| REQ      | 0 = Student choosing to take no more 
          | required science courses  
          | 1 = Student choosing to take one or more 
          | required science courses |
| OPT      | 0 = Student choosing to take no more 
          | elective science courses  
          | 1 = Student choosing to take one or more 
          | elective science courses |

(table continues)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQTOT</td>
<td>Total of required courses and prerequisites taken</td>
</tr>
<tr>
<td>OPTTOT</td>
<td>Total of elective courses and prerequisites taken</td>
</tr>
<tr>
<td>DADSCI</td>
<td>Occupation</td>
</tr>
<tr>
<td></td>
<td>0 = Non-science Related</td>
</tr>
<tr>
<td></td>
<td>1 = Science Related</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>Occupation</td>
</tr>
<tr>
<td></td>
<td>0 = Non-science Related</td>
</tr>
<tr>
<td></td>
<td>1 = Science Related</td>
</tr>
<tr>
<td>DADED</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td>1 = Less Than High School (K-12)</td>
</tr>
<tr>
<td></td>
<td>2 = High School / GED</td>
</tr>
<tr>
<td></td>
<td>3 = Associate's Degree (2 Year)</td>
</tr>
<tr>
<td></td>
<td>4 = Bachelor's Degree (4 Year)</td>
</tr>
<tr>
<td></td>
<td>5 = Master's Degree</td>
</tr>
<tr>
<td></td>
<td>6 = Doctorate / Professional Degree</td>
</tr>
</tbody>
</table>
(table 3 continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOMED</td>
<td>Education</td>
</tr>
<tr>
<td></td>
<td>1 = Less Than High School (K-12)</td>
</tr>
<tr>
<td></td>
<td>2 = High School / GED</td>
</tr>
<tr>
<td></td>
<td>3 = Associate's Degree (2 Year)</td>
</tr>
<tr>
<td></td>
<td>4 = Bachelor's Degree (4 Year)</td>
</tr>
<tr>
<td></td>
<td>5 = Master's Degree</td>
</tr>
<tr>
<td></td>
<td>6 = Doctorate / Professional Degree</td>
</tr>
<tr>
<td>SCIA* (Attitude toward science)</td>
<td>1 = Strongly Disagree</td>
</tr>
<tr>
<td></td>
<td>2 = Disagree</td>
</tr>
<tr>
<td></td>
<td>3 = Neutral</td>
</tr>
<tr>
<td></td>
<td>4 = Agree</td>
</tr>
<tr>
<td></td>
<td>5 = Strongly Agree</td>
</tr>
<tr>
<td>TAI** (Test anxiety, including</td>
<td>1 = Almost Never</td>
</tr>
<tr>
<td>components worry (TAIW) and</td>
<td>2 = Sometimes</td>
</tr>
<tr>
<td>emotionality (TAIE)</td>
<td>3 = Often</td>
</tr>
<tr>
<td></td>
<td>4 = Almost Always</td>
</tr>
<tr>
<td>Variable</td>
<td>Code</td>
</tr>
<tr>
<td>-----------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>SAI** (Science anxiety)</td>
<td>1 = Very Calm</td>
</tr>
<tr>
<td></td>
<td>2 = Fairly Calm</td>
</tr>
<tr>
<td></td>
<td>3 = Neutral</td>
</tr>
<tr>
<td></td>
<td>4 = A Little Nervous</td>
</tr>
<tr>
<td></td>
<td>5 = Very Nervous</td>
</tr>
</tbody>
</table>

* Higher scores indicate positive attitudes

** Higher scores indicate high anxiety

The first objective of the pilot study was to obtain an estimate of the reliability of the instruments used with this population. The internal consistency reliabilities of each scale, including the four-item science attitude scale designed for this study, were quite high for this age group considering the size of the sample (See Table 4). This result is quite favorable, especially since the Science Anxiety Inventory was designed for young children, and at most had previously been administered to high school students. Therefore it appears to be reliable for college age students as well. Also in Table 4 are the means, standard deviations, and ranges of the instruments. For the
Table 4

Descriptive Statistics and Reliabilities (Chronbach's Alpha) of the Instruments Used in Pilot Study

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Items</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Neutral Score</th>
<th>Reliability (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIA</td>
<td>4</td>
<td>16.88</td>
<td>4.14</td>
<td>4.00-20.00</td>
<td>12.00</td>
<td>0.77</td>
</tr>
<tr>
<td>TAI</td>
<td>20</td>
<td>40.16</td>
<td>14.22</td>
<td>20.00-71.00</td>
<td>50.00</td>
<td>0.96</td>
</tr>
<tr>
<td>TAIE</td>
<td>8</td>
<td>17.08</td>
<td>5.98</td>
<td>8.00-31.00</td>
<td>20.00</td>
<td>0.93</td>
</tr>
<tr>
<td>TAIW</td>
<td>8</td>
<td>14.60</td>
<td>5.89</td>
<td>8.00-29.00</td>
<td>20.00</td>
<td>0.92</td>
</tr>
<tr>
<td>SAI</td>
<td>40</td>
<td>86.52</td>
<td>27.33</td>
<td>43.00-136.00</td>
<td>120.00</td>
<td>0.96</td>
</tr>
</tbody>
</table>

SCIA, higher scores indicate more positive attitudes toward science, and lower scores indicate more negative attitudes. With the other scales, the TAI, TAIE, TAIW, and SAI, higher scores imply high levels of anxiety and lower scores, lower levels of anxiety. The results indicate that, for the pilot sample, attitudes toward science (SCIA) were favorable, and test anxiety overall (TAI) in addition to both worry (TAIW) and emotionality (TAIE) were somewhat below the neutral score as was science anxiety (SAI). The mean score for the SCIA (16.88) was somewhat above
the neutral score (12.00). Between the two subcomponents of test anxiety, the worry component resulted in a somewhat lower mean score suggesting that there may have been a lower level of worry than of emotionality with this sample. The descriptive statistics of the independent variables can be seen in Table 5.

Table 6 presents the significant Pearson Product-Moment correlation coefficients for all the variables. Those correlations that were significant at p levels of 0.10, 0.05, and 0.01 or less were listed. Due to the exploratory nature of the pilot, the level of significance was set at $p \leq 0.10$ so that possible relations would not be overlooked.

The variables were grouped as they relate to course of study variables (GEN, MAJ, MORSCI, REQ, OPT, REQTOT, and OPTTOT), parent background (DADSCI, MOMSCI, DADED, and MOMED), and response variables (TAIE, TAIW, SCIA, and SAI). The TAI was dropped from correlation and regression analysis as it is a composite of TAIE and TAIW. Also, for the pilot study, the variable of major was dropped since the majority of the sample (93%) was declared science majors, thus outweighing non-science majors and any relationships would be effected by the unequal distribution.
### Table 5

**Descriptive Statistics of Independent Variables - Pilot Study**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td>25</td>
<td>1.60</td>
<td>0.50</td>
</tr>
<tr>
<td>MORSCI</td>
<td>25</td>
<td>0.88</td>
<td>0.33</td>
</tr>
<tr>
<td>REQ</td>
<td>25</td>
<td>0.84</td>
<td>0.37</td>
</tr>
<tr>
<td>OPT</td>
<td>25</td>
<td>0.56</td>
<td>0.51</td>
</tr>
<tr>
<td>REQTOT</td>
<td>25</td>
<td>11.28</td>
<td>8.50</td>
</tr>
<tr>
<td>OPTTOT</td>
<td>25</td>
<td>11.32</td>
<td>8.65</td>
</tr>
<tr>
<td>DADSCI</td>
<td>25</td>
<td>0.28</td>
<td>0.46</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>25</td>
<td>0.16</td>
<td>0.37</td>
</tr>
<tr>
<td>DADED</td>
<td>25</td>
<td>3.32</td>
<td>1.68</td>
</tr>
<tr>
<td>MOMED</td>
<td>25</td>
<td>2.60</td>
<td>1.15</td>
</tr>
</tbody>
</table>
Table 6

Significant Pearson Product-Moment Correlations Among Variables and Science

Anxiety in the Pilot Study

<table>
<thead>
<tr>
<th></th>
<th>GEN</th>
<th>MORSCI</th>
<th>REQ</th>
<th>OPT</th>
<th>REQTOT</th>
<th>OPTTOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.39*</td>
</tr>
<tr>
<td>MORSCI</td>
<td>0.85***</td>
<td>0.42**</td>
<td></td>
<td>-0.52***</td>
<td>-0.52***</td>
<td></td>
</tr>
<tr>
<td>REQ</td>
<td></td>
<td></td>
<td></td>
<td>-0.40**</td>
<td>-0.41**</td>
<td></td>
</tr>
<tr>
<td>OPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.99***</td>
</tr>
<tr>
<td>OPTTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td>0.36*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td></td>
<td>-0.35*</td>
<td>-0.38*</td>
<td></td>
</tr>
<tr>
<td>TAIW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td>0.38*</td>
<td>0.36*</td>
<td></td>
<td>-0.38*</td>
<td>-0.39*</td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(table continues)*

67
(table 6 continued)

<table>
<thead>
<tr>
<th></th>
<th>DADSCI</th>
<th>MOMSCI</th>
<th>DADED</th>
<th>MOMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DADSCI</td>
<td>0.75***</td>
<td>0.38*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td></td>
<td>0.54***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td></td>
<td></td>
<td>0.59***</td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TAIW</th>
<th>TAIE</th>
<th>SCIA</th>
<th>SAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAIW</td>
<td>0.85***</td>
<td>-0.43**</td>
<td>0.46**</td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td>-0.36*</td>
<td></td>
<td>0.50***</td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p < 0.10, two-tailed, **p < 0.05, two-tailed, ***p < 0.01, two-tailed

68
Gender was negatively related to more elective courses \( r = -0.39, \ p \leq 0.10 \). This meant males were more likely to take more science courses as electives than females. There was no correlation to worry, emotionality, or science anxiety.

Other course of study variables illustrated a few patterns. Those who said they would be taking more science courses (MORSCI) had taken fewer required (REQTOT) and elective (OPTTOT) courses \( r = -0.52, \ p \leq 0.01; \ r = -0.52, \ p \leq 0.01 \). This makes sense as those who needed to take more courses would most likely have lower totals. When asked what type of course (required or elective) would be taken when a student had replied in the affirmative to whether or not they would be taking more science courses, there was a stronger correlation to the required type \( r = 0.85, \ p \leq 0.01 \) than to the elective type \( r = 0.42, \ p \leq 0.05 \). That is, more students were planning to take required courses. As the sample consisted mostly of science majors, they would be planning on taking more required courses. Fewer students were going to take elective science courses. The students who said they would take more science courses also were more likely to have a positive attitude toward science \( r = 0.38, \ p \leq 0.10 \).

Looking at parent background variables, more patterns developed. There was a high correlation between a father's occupation and level of education \( r = 0.75, \ p \leq 0.01 \). This meant that if the father had a higher level of education, he was more likely to have a science-related career. This pattern also was true for mothers, where the correlation between science related occupation and level of education was \( r = 0.54, \ p \leq 0.01 \).
\( p \leq 0.01 \). Level of education between parents was also related \( (r = 0.59, \ p \leq 0.01) \). This meant parents had similar educational levels. Beyond information about parents themselves are the perhaps more meaningful findings. Mothers' background seemed to affect course of study more than fathers' background. In this sample, the students with mothers who had lower levels of education were more likely to be expecting to take more science courses, both required and elective \( (r = -0.35, \ p \leq 0.10; \ r = -0.38, \ p \leq 0.10) \). This is not an expected relationship and the factors which may be involved are not obvious.

Finally, examination of the response variables, that is, worry, emotionality, and attitude toward science, disclosed an expected pattern. A high positive correlation was found between the test anxiety components of worry and emotionality \( (r = 0.85, \ p \leq 0.01) \). Attitude toward science negatively correlated to both worry (TAIW) and emotionality (TAIE) \( (r = -0.43, \ p \leq 0.05; \ r = -0.36, \ p \leq 0.05) \). This meant that those with low levels of worry and emotionality (elements of test anxiety) are more apt to have positive attitudes toward science.

**Full Study**

**Sample**

The study consisted of a total sample and a subsample. The total sample consisted of 166 students, but this number dropped to 152 for analysis due to missing data. The sample included students from two Microbiology courses for science majors, and one Biology course for non-majors during the Autumn 1995 quarter at a large university. The gender distribution was 51% male and 49% female. Distribution
of major was 53% science related, 37% non-science, and 9% undecided. The undecided students were combined with the non-science major group for analysis. A subsample consisting of those students who returned consent forms allowing the release of records from which grades, the measure of achievement, was used. The total sample studied the relationships of all variables except achievement.

In the subsample, (N = 43), there were 35% males and 65% females. The distribution of majors was 86% science major, 11% non-science major, and 2% undecided. These 43 students were used to explore relationships of all other variables and achievement.

One problem with both the sample and subsample was that it was one of convenience and not random and this is a source of sample bias. Therefore, questions related to demographic characteristics were included in the data collection in order to characterize the sample. At the very least, it is hoped that the results will be generalizable to the students at the university from which the sample was obtained, if not to other students at the college level at other institutes of higher learning.

There are two sampling problems related to the subsample. First is the problem of self selection bias. Those who volunteered to release their grades may be different from those who did not. Perhaps the volunteers were interested in contributing to a better understanding of science anxiety, or may believe volunteering would be to their advantage in some other way. The second problem with the subsample is that it is small in relation to the number of variables studied. These
characteristics should be kept in mind when generalizing results as they are inherent limitations of the study.

**Instrumentation**

The instruments used in this research (See Appendix A) consist of three parts and took approximately fifteen minutes to complete. Spielberger's Test Anxiety Inventory (TAI) was the first part, used to ascertain the Test Anxiety, and Worry and Emotionality scores. This instrument was chosen as it was one of the most reliable and most used of the test anxiety instruments. It consists of twenty items, eight of which specifically measure worry, and another eight which measure emotionality. The other four were not used as they were part of the total test anxiety, a concept not studied as stated previously. The second part was the Czerniak Assessment of Science Anxiety (CASA), a forty-item instrument used to acquire a science anxiety score. This instrument was used because it is the only known published instrument designed to measure science anxiety. These two existing instruments (TAI and CASA) along with reliability and validity studies were described previously in Chapter 2.

The last part contained questions concerning the independent variables other than test anxiety or science anxiety. The students were asked to provide gender type, which courses students had taken at the university, whether or not more science courses would be taken and if they would be required or elective, course of study, attitude toward science, and finally parents' occupation and education level. The question regarding courses taken was completed by placing an R for required and E for elective next to the appropriate courses on a listing of courses at the university.
(See Appendix B). This list was obtained from course requirements from the College of Arts and Sciences guidelines for General Education, and the Biological Requirements both at the university. As there were a variety of choices available, and since some requirements stated only credit hours not specific courses, other courses had to be added to the list besides those named in any requirement. These additional courses were selected from the university Bulletin under the science headings found as categories in the list, for example, Microbiology or Zoology.

Students were asked to give the occupation of each parent, then these occupations were coded according to the list. Appendix C lists the occupation types and examples of each. This list was adapted from one developed by Nam and Powers (1983). Finally, they were asked to give the level of education each parent had completed.

Data Collection

The instrument was given at the beginning of the Autumn 1995 session to students in laboratory sections in courses listed in the Sample section. As with the pilot study, the instrument was administered in laboratory courses before laboratory instruction began. The same instructions used for the pilot were given to the students. They were informed that completion of the requested information was completely voluntary and confidential.

Data Analysis

Coding of the demographic information was done after responses were collected. Data was entered onto a computer via Wylbur and the university mainframe
computer. All analyses were done using the appropriate procedures from the SPSS computer analysis package. To evaluate research statement 1, the correlation coefficients were calculated for each of the independent variables in relation to the dependent variable of science anxiety.

From the review of literature, a hypothesized model is proposed and can be found in Figure 1. Placement of most lines has been verified by the literature. Gender is a variable linked to both test anxiety and science anxiety (Chiarello & Czerniak, 1987; Hembree, 1988; Zoller & Ben-Chiam, 1988; Wynstra & Cummings, 1990; Anderson & Clawson, 1992). The only direction possible is gender to the other two variables as neither test anxiety nor science anxiety could cause gender. The line connecting gender and attitude toward science is hypothesized following the logic that since attitude toward science affects science anxiety or vice versa, directionality is uncertain (Mallow, 1981; Gabel, 1981), and since gender affects science anxiety directly, perhaps it does so also indirectly through attitude toward science.

Parent background is another variable whose affect is only possible in one direction. Parent background affects attitude toward science (Mallow, 1981; Simpson & Oliver, 1990; Germann, 1994). Student attitude should not affect parent background, as background is already determined as is gender. The other lines, again in one direction, are hypothesized using the same logic used previously. There is a direct effect between parent background and student attitude toward science, so there are possible indirect effects between parent background and those variables that student attitude toward science directly or indirectly affects. This would be the case

74
Figure 1. Hypothesized model of science anxiety and the variables gender, course of study, parent background, test anxiety, and attitude toward science.
with course of study which is directly linked to student attitude toward science (Gabel, 1981), test anxiety, which is linked to science anxiety then attitude toward science, and finally science anxiety which is also linked to attitude toward science.

This "missing link" logic completes the connections related to course of study. Course of study and test anxiety affect each other (Zoller & Ben-Chiam, 1988; Everson et al., 1991) and test anxiety and science anxiety affect each other, therefore, it is hypothesized that there may be a direct link between course of study and science anxiety as well. Again, directionality is unknown. Does science anxiety affect course of study choice, is the reverse true, or are both true?

Insight as to how the variables related to science anxiety in this study was gained by way of simple correlation and multiple linear regression of the data collected. Analysis for the achievement subsample was restricted to descriptive and simple correlation due to the sample size and the bias due to the volunteer nature of the sample. In the multiple linear regression analyses, first, all variables were included in one model; second, a stepwise inclusion of independent variables was done to determine if a better linear model could be achieved; and finally, as worry, emotionality, and attitude toward science appear to be highly associated with science anxiety, stepwise multiple linear regression analyses utilizing variables TAIE, TAIW, and SCIA as separate dependent variables were computed to see how they might relate to the independent variables.
Summary

The research done in this study was descriptive and exploratory in nature. It was designed to investigate relationships between the dependent variable Science Anxiety and the independent variables Test Anxiety and its components Worry and Emotionality, Gender, Parent Background, Course of Study, Achievement, and Attitude Toward Science. A pilot study using a sample of students in science courses at a large university was done to establish reliability of the instrument for use with college-aged subjects and to give further direction for analysis of the total sample data. The reliabilities of the various instruments were high (internal consistency range was $\alpha = 0.77-0.96$). The pilot sample displayed low levels of test anxiety, worry, emotionality, and science anxiety, and favorable attitudes toward science when related to a "neutral" score. Correlations provided a few patterns. Males were more likely to take more science courses. Those who did plan to take more science courses had better attitudes toward science. Those with low test anxiety worry and emotionality had better attitudes toward science and lower levels of science anxiety. This could mean that there is an indirect relationship between science anxiety and attitude toward science. These preliminary results may indicate 1) females are not interested or not encouraged to take science courses, and 2) a decrease in test anxiety is associated with improvement in attitude toward science and a decrease in science anxiety.

The sample for the main study was similar to that of the pilot study. It consisted of students in science courses at a large university. The data collection for this study utilized a combination of two published instruments to measure science
anxiety and test anxiety, an instrument designed to obtain information related to
gender, course of study, parent background characteristics, and a published instrument
to measure attitude toward science.

Variables were chosen by determining those deemed important either by
numerous citations in the literature or by lack of research. Data was analyzed with the
SPSS computer analysis package and descriptive, correlational, and regression
statistics were calculated. Models were hypothesized based on the literature.
CHAPTER 4

RESULTS

The results will be presented in two parts. The first reports the results of the full sample (N = 152) without the inclusion of the achievement variable. The second gives the results of the subsample (N = 43) including the achievement variable.

Results of the Total Sample

Means, Standard Deviations, Reliabilities of the Instruments Included in the Data Collection

Descriptive statistics of the independent variables related to gender, course of study, and parent characteristics are summarized in Table 7. The general description of the sample population is based on the data gathered. As stated previously, 49% of the sample was female and 51% was male, and 53% of the sample expressed that they had science related majors, while 47% claimed either to have non-science related majors or to be undecided. 84% of the sample said they would take more science
### Table 7

**Descriptive Statistics of Independent Variables - Total Sample**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td>152</td>
<td>1.49</td>
<td>0.50</td>
</tr>
<tr>
<td>MAJ</td>
<td>152</td>
<td>1.53</td>
<td>0.50</td>
</tr>
<tr>
<td>MORSCI</td>
<td>152</td>
<td>0.84</td>
<td>0.37</td>
</tr>
<tr>
<td>REQ</td>
<td>152</td>
<td>0.80</td>
<td>0.40</td>
</tr>
<tr>
<td>OPT</td>
<td>152</td>
<td>0.49</td>
<td>0.51</td>
</tr>
<tr>
<td>REQTOT</td>
<td>152</td>
<td>26.85</td>
<td>35.44</td>
</tr>
<tr>
<td>OPTTOT</td>
<td>152</td>
<td>26.82</td>
<td>35.45</td>
</tr>
<tr>
<td>DADSCI</td>
<td>152</td>
<td>0.23</td>
<td>0.42</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>152</td>
<td>0.16</td>
<td>0.37</td>
</tr>
<tr>
<td>DADED</td>
<td>152</td>
<td>3.63</td>
<td>1.53</td>
</tr>
<tr>
<td>MOMED</td>
<td>152</td>
<td>3.11</td>
<td>1.26</td>
</tr>
</tbody>
</table>

80
courses, 80% said they would take more required science courses, and 49% said they would take more elective science courses.

As to the parent background results, 23% had fathers with science related occupations and 16% had mothers with science related occupations. Educational levels of fathers and mothers averaged between completion of a 2 year college degree and a 4 year Bachelor's degree.

The descriptive statistics of the data obtained from instruments used in this study are summarized in Table 8. As with the pilot study, it can be seen that the attitude toward science (SCIA) is positive. The mean score for this measure was 16.51, near the upper end of the scale. The maximum score possible and thus most positive attitude would be a score of 20.00. There were a total of 4 items on the measure, so this mean would equate to an average of 4.13 on a scale of 1 to 5, 5 being the most positive attitude score. The reliability of this measure was higher for the total sample than for the pilot. Here, the internal consistency reliability of the attitude toward science measure was 0.80 compared to the 0.77 in the pilot.

The mean for total test anxiety (TAI) was 39.30. This score, being less than the neutral score, indicates a low level of test anxiety overall. Similar results can be seen for both the worry (TAIW) and emotionality (TAIE) components where the means were less than the neutral score. The TAIW mean appears to be slightly less than the mean of TAIE implying perhaps that there were lower levels of worry than emotionality with this sample. However, a pairwise t-test indicates this difference is not significant ($p < 0.05$).
Table 8

**Descriptive Statistics and Reliabilities (Chronbach's Alpha) of the Instruments Used - Total Sample**

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Items</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Neutral Score</th>
<th>Reliability (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIA</td>
<td>4</td>
<td>16.51</td>
<td>3.13</td>
<td>4.00-20.00</td>
<td>12.00</td>
<td>0.80</td>
</tr>
<tr>
<td>TAI</td>
<td>20</td>
<td>39.30</td>
<td>12.26</td>
<td>20.00-73.00</td>
<td>50.00</td>
<td>0.94</td>
</tr>
<tr>
<td>TAIE</td>
<td>8</td>
<td>16.69</td>
<td>5.65</td>
<td>8.00-31.00</td>
<td>20.00</td>
<td>0.91</td>
</tr>
<tr>
<td>TAIW</td>
<td>8</td>
<td>14.20</td>
<td>4.92</td>
<td>8.00-28.00</td>
<td>20.00</td>
<td>0.87</td>
</tr>
<tr>
<td>SAI</td>
<td>40</td>
<td>87.36</td>
<td>26.19</td>
<td>40.00-147.00</td>
<td>120.00</td>
<td>0.96</td>
</tr>
</tbody>
</table>

All three measures, the TAI overall and the two subscales, TAIE and TAIW had very high internal consistency reliabilities from this sample ranging from 0.87-0.94. They are comparable with those found in other research done using this instrument.

Finally, the results of the science anxiety instrument (SAI) indicate a low yet existing level of science anxiety. The mean of 87.36 was low, less than the neutral score of 120.00. The high reliability of this instrument (0.96) is somewhat surprising
in that the instrument was designed for 5th graders and was not modified for use with college age students.

**Correlational Results**

Correlations were computed for all pairs of variables. Table 9 is the report of the correlations significant at the 0.05 and 0.01 levels. As with the pilot, the correlation table was divided into parts, with headings grouped by similar variables or variable types. These groups were gender, course of study, parent background, and dependent or response variables (TAIW, TAIE, SCIA, and SAI).

The variables related to gender and course of study - major, more science, required, and elective courses are given first. There was a moderate correlation between gender and science anxiety \( r = 0.24, p < 0.01 \). This result is consistent with other research, that females tend to be more anxious about science than males.

Another interesting relationship is the correlation between gender and major \( r = 0.17, p < 0.05 \). In this sample, females, more than males, were pursuing a science course of study. This may in some way be related to the life science focus of the science course groups in the sample. However, the low magnitude of correlation must be kept in mind.

As would be expected, there is an overall positive correlation between major and the indicators of involvement in science - whether or not more science courses will be taken \( r = 0.40, p < 0.01 \), if students will take more required \( r = 0.40, p < 0.01 \) or elective \( r = 0.41, p < 0.01 \) science courses, and total numbers of required science courses plus prerequisites \( r = 0.52, p < 0.01 \) and elective science
<table>
<thead>
<tr>
<th></th>
<th>GEN</th>
<th>MAJ</th>
<th>MORSCI</th>
<th>REQ</th>
<th>OPT</th>
<th>REQTOT</th>
<th>OPTTOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td></td>
<td>0.17**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAJ</td>
<td>0.40***</td>
<td>0.40***</td>
<td>0.41***</td>
<td>0.52***</td>
<td>0.52***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MORSCI</td>
<td></td>
<td>0.89***</td>
<td>0.43***</td>
<td>0.29***</td>
<td>0.29***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ</td>
<td>0.32***</td>
<td></td>
<td>0.28***</td>
<td></td>
<td>0.28***</td>
<td>0.41***</td>
<td>0.41***</td>
</tr>
<tr>
<td>OPT</td>
<td>0.41***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.99***</td>
</tr>
<tr>
<td>REQTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADSCI</td>
<td>0.20**</td>
<td></td>
<td></td>
<td>0.21**</td>
<td>0.26***</td>
<td>0.27***</td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.22***</td>
<td>0.22***</td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td>-0.19**</td>
<td></td>
<td></td>
<td>0.17**</td>
<td>0.22***</td>
<td>0.22***</td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td>0.50***</td>
<td>0.23***</td>
<td>0.21***</td>
<td>0.40***</td>
<td>0.40***</td>
<td>0.40***</td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td>0.24***</td>
<td></td>
<td></td>
<td></td>
<td>-0.16**</td>
<td>-0.16**</td>
<td></td>
</tr>
</tbody>
</table>

*(table continues)*
(table 9 continued)

<table>
<thead>
<tr>
<th></th>
<th>DADSCI</th>
<th>MOMSCI</th>
<th>DADED</th>
<th>MOMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DADSCI</td>
<td>0.41***</td>
<td>0.42***</td>
<td></td>
<td>0.20**</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>0.18**</td>
<td></td>
<td></td>
<td>0.28***</td>
</tr>
<tr>
<td>DADED</td>
<td></td>
<td></td>
<td>0.63***</td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td>0.26***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td></td>
<td>-0.18**</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TAIW</th>
<th>TAIE</th>
<th>SCIA</th>
<th>SAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAIW</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.74***</td>
<td></td>
<td></td>
<td></td>
<td>0.56***</td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.53***</td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.27***</td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**p ≤ 0.05, two-tailed,   ***p ≤ 0.01, two-tailed
courses plus prerequisites ($r = 0.52, \ p \leq 0.01$). First, it must be noted from these results and other correlations related to the variables REQTOT and OPTTOT that these variables are very highly correlated even though they are not identical variables. These relationships simply indicate that it is more likely that science majors have been and will continue to be more involved with science courses than non-science majors. In regard to the correlation of major with elective courses, it may be that science majors take elective courses within the required curriculum. They tend to have a choice of which science course they will take to fulfill that requirement. However, non-science majors have a free choice as to taking or avoiding science courses.

The parent background variables showed some interesting patterns. Students who have fathers with a science-related occupation and higher level of education, are more likely to be science majors ($r = 0.20, \ p \leq 0.05$). Thus as majors they are more likely to have greater involvement in higher level courses (REQTOT and OPTTOT).

The table also illustrates the relationships among attitudes and anxieties. As with the pilot, the components of test anxiety (TAIE and TAIW) are highly correlated to each other ($r = 0.74, \ p \leq 0.01$). Science majors (MAJ) tend to have better attitudes toward science (SCIA) indicated by a coefficient of $r = 0.50 (p \leq 0.01)$. Another pattern concerning attitudes toward science is that those who plan to take and/or have taken more science courses have more positive attitudes toward science. Those whose fathers have science related occupations tend to have more positive attitudes toward
science \( (r = 0.26, p \leq 0.01) \). Finally, SCIA correlates with TAIW \( (r = -0.18, p \leq 0.05) \) but not with TAIE. Attitude toward science is related to test anxiety worry.

With regards to science anxiety itself, besides the correlation with gender mentioned earlier, SAI is correlated to both TAIW \( (r = 0.56, p \leq 0.01) \) and TAIE \( (r = 0.53, p \leq 0.01) \) as well as with SCIA \( (-0.27, p \leq 0.01) \). The lower the worry and emotionality, the lower the science anxiety. The more positive the attitude toward science is, the lower the science anxiety. It is not clear whether lower science anxiety results in an improved attitude toward science, or does an improved attitude toward science result in lowered science anxiety or both.

The groupings used here in the correlations seem to show some patterns, so the same groupings - according to gender, course of study, parental background, and response variables (test anxiety worry, test anxiety emotionality, and attitude toward science) were used in the multiple regression analyses. The patterns can be seen in the summary of correlations (See Figure 2). As would be expected, the variables within the groupings, especially those variables in the course of study group, are generally correlated to each other. There are also a large number of variables, in fact at least one from each group, correlated to attitude toward science. This variable, then, may have a pivotal role and merit further attention.
Figure 2. Summary of the correlation coefficients for the variables GEN*, MAJ, MORSCI, REQ, OPT, REQTOT, OPTTOT, DADSCI, MOMSCI, DADED, MOMED, SCIA, TAIE, TAIW, and SAI - Total Sample (p ≤ 0.001)

* Included for comparative purposes with the hypothesized model.
Multiple Regression Results

Multiple regression analyses were done in three stages. First, a regression analysis was done with all independent and dependent variables at once and with science anxiety as the dependent variable. This was done in order to get an overall picture to which other models may be compared. This was followed by a stepwise regression procedure in search of a "best fit" model. This method entered the best predictor, then the next, and so on until there were no more variables left that contributed significantly to the prediction at the $p \leq 0.05$ level. Finally, three additional stepwise analyses were done using the other response variables, worry (TAlW), emotionality (TAIE), and attitude toward science (SCI A) as dependent variables. In these analyses, only the independent variables from the groups gender, course of study, and parent background were included as potential predictors.

In all cases, raw beta coefficients, standard errors, standardized betas, significant $p$-values, constants, and $R^2$s were reported. The beta coefficients represent the standardized regression coefficients for each variable in a given regression line. They indicate the relative importance or predictive power of each variable in the set. The $p$-values suggest which variables contribute significantly to the prediction of the dependent variable.

Multiple Linear Regression Analysis

Table 10 reports the summary of the regression analysis when all variables are entered with science anxiety as the dependent variable. The linear model explaining the most variance would have the regression coefficients listed in the table. The $R^2$
indicates that, when all variables are taken into consideration, they explain 47% of the variance in science anxiety.

Three groups of variables tend to emerge. The variables REQ, MORSCI, TAIE, and TAIW have standardized betas ranging from 0.29-0.37. They have approximately twice the influence on prediction as those in the second group - SCIA, GEN, and MOMED whose standardized betas range from 0.16-0.18. The third group, the remaining variables, do not individually significantly contribute to the prediction. The resulting standardized regression equation would be:

\[ SAI = -0.37(REQ) + 0.33(MORSCI) + 0.32(TAIE) + 0.29(TAIW) - 0.18(SCIA) + 0.17(GEN) - 0.16(MOMED) \]

**Stepwise Linear Regression Analyses**

**Science Anxiety**

The summary of the stepwise linear regression analysis for science anxiety (SAI) is found in Table 11. This analysis results in the selection of five variables as the set of significant \( (p \leq 0.05) \) predictors for science anxiety. The variables chosen include the worry component of test anxiety (TAIW) and accounts for 31% of variability in science anxiety; mother’s education level (MOMED) accounting for an additional 4%; TAIE, accounting for an additional 4%; attitude toward science (SCIA) accounting for an additional 3%; and GEN, accounting for an additional 2% of the variance in science anxiety. With these data, these five variables account for 44% of the variation in science anxiety. Addition of all the other variables would
Table 10

Summary of the Multiple Linear Regression Analysis of the Predictor Variables of Science Anxiety - Total Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>REQ</td>
<td>-24.52</td>
<td>9.56</td>
<td>-0.37</td>
<td>0.01</td>
</tr>
<tr>
<td>MORSCI</td>
<td>23.46</td>
<td>10.53</td>
<td>0.33</td>
<td>0.03</td>
</tr>
<tr>
<td>TAIE</td>
<td>1.47</td>
<td>0.44</td>
<td>0.32</td>
<td>0.00</td>
</tr>
<tr>
<td>TAIW</td>
<td>1.54</td>
<td>0.51</td>
<td>0.29</td>
<td>0.00</td>
</tr>
<tr>
<td>SCIA</td>
<td>-1.49</td>
<td>0.64</td>
<td>-0.18</td>
<td>0.02</td>
</tr>
<tr>
<td>GEN</td>
<td>8.69</td>
<td>3.48</td>
<td>0.17</td>
<td>0.01</td>
</tr>
<tr>
<td>MOMED</td>
<td>-3.32</td>
<td>1.78</td>
<td>-0.16</td>
<td>0.06</td>
</tr>
<tr>
<td>DADSCI</td>
<td>-3.08</td>
<td>4.84</td>
<td>-0.05</td>
<td>0.53</td>
</tr>
<tr>
<td>DADEED</td>
<td>-0.35</td>
<td>1.59</td>
<td>-0.02</td>
<td>0.83</td>
</tr>
<tr>
<td>OPTTOT</td>
<td>-0.02</td>
<td>0.06</td>
<td>-0.02</td>
<td>0.79</td>
</tr>
<tr>
<td>MAJ</td>
<td>1.37</td>
<td>4.52</td>
<td>0.03</td>
<td>0.76</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>1.14</td>
<td>5.22</td>
<td>0.02</td>
<td>0.83</td>
</tr>
<tr>
<td>OPT</td>
<td>0.56</td>
<td>4.01</td>
<td>0.01</td>
<td>0.89</td>
</tr>
<tr>
<td>Constant</td>
<td>62.85</td>
<td>13.33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note. \( R^2 = 0.47 \). *p ≤ 0.05.
only increase this percentage by 3%. These are then the most efficient predictors, taken in combination, to predict science anxiety. The resulting regression equation would be:

\[ SAI = 0.31(\text{TAIE}) + 0.28(\text{TAIW}) - 0.19(\text{MOMED}) - 0.18(\text{SCIA}) + 0.15(\text{GEN}) \]

**Test Anxiety - Worry**

At the level of probability \( p \leq 0.05 \), there were no variables to be entered. Apparently, none of the parent background or course of study variables contributed directly to test anxiety worry as a dependent variable.

**Test Anxiety - Emotionality**

As with test anxiety worry, emotionality did not have any significant predictors among the parent background or course of study variables.

**Attitude Toward Science**

Significant predictors were computed from the stepwise linear regression analysis of attitude toward science (See Table 12). The first variable selected by the computer was major (MAJ). This variable accounted for 25% of the variability. The second variable chosen was more elective courses (OPT). This improved variability explanation to 30%. When the third and last variable, father’s occupation (DADSCI), was added, \( R^2 \) only increased to 32%. These three variables, then, are the best combination of three
Table 11

Summary of the Hierarchical Stepwise Linear Regression Analysis for the Predictor Variables of Science Anxiety - Total Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
<th>R²</th>
<th>Δ R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAIE</td>
<td>1.45</td>
<td>0.43</td>
<td>0.31</td>
<td>0.00</td>
<td>0.31</td>
<td>0.31</td>
</tr>
<tr>
<td>TAIW</td>
<td>1.49</td>
<td>0.50</td>
<td>0.28</td>
<td>0.00</td>
<td>0.35</td>
<td>0.04</td>
</tr>
<tr>
<td>MOMED</td>
<td>-3.87</td>
<td>1.31</td>
<td>-0.19</td>
<td>0.00</td>
<td>0.39</td>
<td>0.04</td>
</tr>
<tr>
<td>SCIA</td>
<td>-1.54</td>
<td>0.53</td>
<td>-0.18</td>
<td>0.00</td>
<td>0.42</td>
<td>0.03</td>
</tr>
<tr>
<td>GEN</td>
<td>7.97</td>
<td>3.29</td>
<td>0.15</td>
<td>0.02</td>
<td>0.44</td>
<td>0.02</td>
</tr>
<tr>
<td>(Constant)</td>
<td>67.64</td>
<td>11.95</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p ≤ 0.05.

from this set of variables for predicting attitude toward science. However, they only explain about one third of the variability. The regression equation is:

\[
\text{SCIA} = 0.39(\text{MAJ}) + 0.21(\text{OPT}) + 0.14(\text{DADSCI})
\]
Table 12

Summary of the Hierarchical Stepwise Linear Regression Analysis for the Predictor

Variables of Attitude Toward Science - Total Sample

<table>
<thead>
<tr>
<th>Variable</th>
<th>B</th>
<th>SE B</th>
<th>β</th>
<th>p</th>
<th>R²</th>
<th>Δ R²</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAJ</td>
<td>2.46</td>
<td>0.46</td>
<td>0.39</td>
<td>0.00</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>OPT</td>
<td>1.27</td>
<td>0.45</td>
<td>0.21</td>
<td>0.01</td>
<td>0.30</td>
<td>0.05</td>
</tr>
<tr>
<td>DADSCI</td>
<td>1.06</td>
<td>0.52</td>
<td>0.14</td>
<td>0.04</td>
<td>0.32</td>
<td>0.02</td>
</tr>
<tr>
<td>(Constant)</td>
<td>11.87</td>
<td>0.68</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*p ≤ 0.05.

Results of the Achievement Subsample

This subsample has at least one advantage and at least one disadvantage. One advantage is that two additional variables have been added to the analyses - achievement - measured by overall grade point average (GPA) and by science grade point average (SGPA). Actually, these two measures act like two variables. One disadvantage is that the sample size is much smaller. The total number in the sample
was 46, a subset of the original 166. This number decreased further to 43 in the regressions due to cases with missing data.

Means, Standard Deviations, Reliabilities of the Instruments Included in the Data Collection

Descriptive data for all independent variables follows in Table 13. With respect to the means, results indicate some similarities and differences compared to the results from pilot and with the full sample. The achievement subsample consisted of 65% females and 35% males. There was a similar discrepancy of gender in the pilot, but the total sample was fairly balanced. The achievement subsample, as with the pilot sample, was primarily science majors (86% science majors versus 14% non-science majors). Again, the total sample was balanced. There was a greater indication that more science courses would be taken (98%) than there was for either the pilot or total samples. All groups were about the same concerning more courses being required (88% of the achievement subsample responded in the affirmative). With regards to more elective courses, 63% of the achievement subsample said they would opt for elective science courses. This was similar to the pilot group, but was a larger proportion when compared to the total sample. All three groups were comparable on all indications of parent background. 33% said their fathers had science related occupations, and 23% said the same of their mothers. Again, both parents completed somewhere between a 2-year degree and a 4-year Bachelor's degree.
Table 13

Descriptive Statistics of Independent Variables - Achievement Subsample

<table>
<thead>
<tr>
<th>Variable</th>
<th>Cases</th>
<th>Mean</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td>43</td>
<td>1.65</td>
<td>0.48</td>
</tr>
<tr>
<td>MAJ</td>
<td>43</td>
<td>1.86</td>
<td>0.35</td>
</tr>
<tr>
<td>MORSCI</td>
<td>43</td>
<td>0.98</td>
<td>0.15</td>
</tr>
<tr>
<td>REQ</td>
<td>43</td>
<td>0.88</td>
<td>0.32</td>
</tr>
<tr>
<td>OPT</td>
<td>43</td>
<td>0.63</td>
<td>0.49</td>
</tr>
<tr>
<td>REQTOT</td>
<td>43</td>
<td>40.51</td>
<td>37.80</td>
</tr>
<tr>
<td>OPTTOT</td>
<td>43</td>
<td>40.51</td>
<td>37.80</td>
</tr>
<tr>
<td>DADSCI</td>
<td>43</td>
<td>0.33</td>
<td>0.47</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>43</td>
<td>0.23</td>
<td>0.43</td>
</tr>
<tr>
<td>DADED</td>
<td>43</td>
<td>3.58</td>
<td>1.53</td>
</tr>
<tr>
<td>MOMED</td>
<td>43</td>
<td>3.21</td>
<td>1.19</td>
</tr>
<tr>
<td>GPA</td>
<td>43</td>
<td>3.00</td>
<td>0.54</td>
</tr>
<tr>
<td>SGPA</td>
<td>43</td>
<td>2.83</td>
<td>0.65</td>
</tr>
</tbody>
</table>
The achievement subsample had a B average overall (3.00 on a 4.00 scale), and between a B and a B- for their science grade (2.83 on a 4.00 scale).

The main difference between the subsample and the total sample, therefore, is the major and gender composition. The subsample had greater numbers of females and science majors than the total sample.

The descriptive data and reliabilities of the instruments from the achievement subsample follows in Table 14. The mean for attitude toward science (17.93) was greater than the neutral score (12.00), thus indicating a positive attitude on average. In fact, the mean with this subsample was slightly larger than either the pilot or the total sample. Results were slightly lower regarding TAI and TAIW (38.05 and 13.28 respectively), indicating an even lower level of test anxiety overall and lower levels of worry in this subsample. The TAIE mean was very similar, indicating a comparable low level of emotionality anxiety. Levels of science anxiety though lower than the total sample, were slightly higher than the pilot, but still indicated low levels of science anxiety overall.

In order to determine if the differences between the means of the the total sample and the achievement subsample were significant, t-tests were calculated between these groups (See Table 15). Group 1 consisted of students who did not give permission to release their grades (total sample - achievement subsample), and Group 2 was the achievement subsample.
Table 14

Descriptive Statistics and Reliabilities (Chronbach's Alpha) of the Instruments Used in Study - Achievement Subsample

<table>
<thead>
<tr>
<th>Variable</th>
<th># of Items</th>
<th>Mean</th>
<th>SD</th>
<th>Range</th>
<th>Neutral Score</th>
<th>Reliability (α)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCIA</td>
<td>4</td>
<td>17.93</td>
<td>2.50</td>
<td>4.00-20.00</td>
<td>12.00</td>
<td>0.80</td>
</tr>
<tr>
<td>TAI</td>
<td>20</td>
<td>38.05</td>
<td>10.93</td>
<td>20.00-73.00</td>
<td>50.00</td>
<td>0.94</td>
</tr>
<tr>
<td>TAIE</td>
<td>8</td>
<td>16.35</td>
<td>5.46</td>
<td>8.00-31.00</td>
<td>20.00</td>
<td>0.91</td>
</tr>
<tr>
<td>TAIW</td>
<td>8</td>
<td>13.28</td>
<td>3.72</td>
<td>8.00-28.00</td>
<td>20.00</td>
<td>0.87</td>
</tr>
<tr>
<td>SAI</td>
<td>40</td>
<td>87.19</td>
<td>24.07</td>
<td>40.00-147.00</td>
<td>120.00</td>
<td>0.96</td>
</tr>
</tbody>
</table>

To determine level of significance, the Bon Ferroni adjustment was calculated to be 0.003. At the $p \leq 0.003$ level of significance, the only variables where there was a significant difference was major (MAJ) with a t-score of -5.54, attitude toward science (SCIA) with a t-score of -3.64, REQTOT (t-score = -3.07), and MORSCI (t-score = -3.02). This means that no difference beyond that of chance were found between the two groups on any of the other variables: GEN, REQ, OPT, DADSCI, MOMSCI, DADED, MOMED, TAIW, TAIE, and SAI.
Table 15

*T-test Scores Between the Total Sample and the Achievement Subsample*

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-Score</th>
<th>Degrees of Freedom</th>
<th>2-Tail Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td></td>
<td></td>
<td>-2.58</td>
<td>150</td>
<td>0.011</td>
</tr>
<tr>
<td>Group 1</td>
<td>1.42</td>
<td>0.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>1.65</td>
<td>0.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAJ</td>
<td></td>
<td></td>
<td>-5.54</td>
<td>150</td>
<td>0.000</td>
</tr>
<tr>
<td>Group 1</td>
<td>1.40</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>1.86</td>
<td>0.35</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MORSCI</td>
<td></td>
<td></td>
<td>-3.02</td>
<td>150</td>
<td>0.003</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.78</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.98</td>
<td>0.15</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ</td>
<td></td>
<td></td>
<td>-1.58</td>
<td>150</td>
<td>0.116</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.77</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.88</td>
<td>0.32</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPT</td>
<td></td>
<td></td>
<td>-2.04</td>
<td>150</td>
<td>0.043</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.44</td>
<td>0.52</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.63</td>
<td>0.49</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQTOT</td>
<td></td>
<td></td>
<td>-3.07</td>
<td>150</td>
<td>0.003</td>
</tr>
<tr>
<td>Group 1</td>
<td>21.46</td>
<td>33.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>40.51</td>
<td>37.80</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPPTOT</td>
<td></td>
<td></td>
<td>-3.07</td>
<td>150</td>
<td>0.003</td>
</tr>
<tr>
<td>Group 1</td>
<td>21.42</td>
<td>33.13</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>40.51</td>
<td>37.80</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*(table continues)*

99
(table 15 continued)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Standard Deviation</th>
<th>t-Score</th>
<th>Degrees of Freedom</th>
<th>2-Tail Probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>DADSCI</td>
<td></td>
<td></td>
<td>-1.76</td>
<td>150</td>
<td>0.081</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.19</td>
<td>0.40</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.33</td>
<td>0.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td></td>
<td></td>
<td>-1.59</td>
<td>150</td>
<td>0.114</td>
</tr>
<tr>
<td>Group 1</td>
<td>0.13</td>
<td>0.34</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>0.23</td>
<td>0.43</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td></td>
<td></td>
<td>0.22</td>
<td>150</td>
<td>0.826</td>
</tr>
<tr>
<td>Group 1</td>
<td>3.64</td>
<td>1.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>3.58</td>
<td>1.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td>-0.64</td>
<td>150</td>
<td>0.525</td>
</tr>
<tr>
<td>Group 1</td>
<td>3.06</td>
<td>1.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>3.21</td>
<td>1.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td></td>
<td>-3.64</td>
<td>150</td>
<td>0.000</td>
</tr>
<tr>
<td>Group 1</td>
<td>15.95</td>
<td>3.19</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>17.93</td>
<td>2.50</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIW</td>
<td></td>
<td></td>
<td>1.46</td>
<td>150</td>
<td>0.146</td>
</tr>
<tr>
<td>Group 1</td>
<td>14.57</td>
<td>5.29</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>13.28</td>
<td>3.73</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td>0.47</td>
<td>150</td>
<td>0.641</td>
</tr>
<tr>
<td>Group 1</td>
<td>16.83</td>
<td>5.74</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>16.35</td>
<td>5.46</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td>0.05</td>
<td>150</td>
<td>0.959</td>
</tr>
<tr>
<td>Group 1</td>
<td>87.43</td>
<td>27.08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group 2</td>
<td>87.19</td>
<td>24.07</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Correlational Results

The achievement subsample results, were compared to the full sample to see if there were any similarities and differences in the two groups. The summary of the correlational results can be seen in Table 16.

There were two similar and four different results concerning the major (MAJ) variable. Both samples indicated positive correlations between choice of major and level of involvement in science, and between major and attitude toward science. The first result, as with the total group is not surprising. Science majors tend to have taken more science courses at higher levels than non-science majors, mainly because they are required to take more courses. They also are more likely to have positive attitudes toward science than the non-science majors.

The differences with the subsample were that there were no correlations between gender and major, between more science and attitude toward science, and between gender and science anxiety. However, for the most part, this subsample consisted of science majors. Major, then, is not really a variable to consider with this subsample. Perhaps gender has no effect on science anxiety if all in a sample are science majors. If the sample is fairly equally distributed between majors and non-majors, the gender variable then seems to have an effect. Or perhaps gender is a factor of importance when non-science majors are included in the sample. In the total sample, science majors were more likely to be female. If science majors have less science anxiety, it should have followed that females also would have had less science anxiety.
Table 16

Significant Pearson Product-Moment Correlations Between Independent Variables and Science Anxiety - Achievement Subsample

<table>
<thead>
<tr>
<th></th>
<th>GEN</th>
<th>MORSCI</th>
<th>MAJ</th>
<th>REQ</th>
<th>OPT</th>
<th>REQTOT</th>
<th>OPTTOT</th>
<th>GPA</th>
<th>SGPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MORSCI</td>
<td>0.38**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MAJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQ</td>
<td>0.34**</td>
<td>0.42***</td>
<td></td>
<td></td>
<td></td>
<td>0.48***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>REQTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OPTTOT</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMED</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SGPA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.88***</td>
</tr>
<tr>
<td>TAIW</td>
<td>0.35**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(table continues)

102
<table>
<thead>
<tr>
<th></th>
<th>DADSCI</th>
<th>MOMSCI</th>
<th>DADED</th>
<th>MOMED</th>
</tr>
</thead>
<tbody>
<tr>
<td>DADSCI</td>
<td>0.44***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MOMSCI</td>
<td></td>
<td>0.42***</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DADED</td>
<td>0.67***</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>TAIW</th>
<th>TAIE</th>
<th>SCIA</th>
<th>SAI</th>
</tr>
</thead>
<tbody>
<tr>
<td>TAIW</td>
<td>0.40***</td>
<td>0.39***</td>
<td>0.36**</td>
<td>0.38**</td>
</tr>
<tr>
<td>TAIE</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAI</td>
<td></td>
<td></td>
<td>0.54***</td>
<td>0.48***</td>
</tr>
</tbody>
</table>

**p ≤ 0.05, two-tailed, ***p ≤ 0.01, two-tailed

This last finding refutes research that states that females are more science anxious than males. A condition should be added - females are more science anxious.
depending on their major. Female science majors do not tend to have more science anxiety than male science majors.

Lastly, there were similarities and differences in correlations concerning the variables related to the instrument measures (TAIW, TAIE, and SCIA). The test anxiety components (TAIW and TAIE) were again correlated to each other \(r = 0.68, p \leq 0.01\). Worry and emotionality were also correlated to science anxiety \(r = 0.54, p \leq 0.01\) and \(r = 0.48, p \leq 0.01\). Attitude toward science was negatively correlated with science anxiety \(r = -0.34, p \leq 0.01\) meaning those students with positive attitudes toward science were more likely to have low levels of science anxiety. Causality can still not be determined. There was one difference. TAIW was not correlated to SCIA.

As stated earlier, the other variables, though not resulting in correlation patterns across groups, still provided some interesting findings with regard to the achievement subsample. One correlation was found in the course of study group of variables. There was a correlation between gender and worry \(r = 0.35, p \leq 0.05\). Females in this group may not tend to be more science anxious, again perhaps because they are mostly science majors, but they are more likely to have higher levels of the test anxiety component worry.

There were also differences with regards to the parent background variables. With the achievement subsample, there was a relationship between father's occupation and both parents education level and more science courses. If the father had a science related occupation and/or if either or both parents had higher levels of education,
students were more likely to take more science courses, specifically, elective science courses \((r = 0.32, p \leq 0.05; r = 0.33, p \leq 0.05; r = 0.30 p \leq 0.05\) for OPT and DADSCI, DADED, and MOMED respectively). Also, if the father had a science related occupation, students were more apt to have better attitudes toward science \((r = 0.40, p \leq 0.01)\). Also, MOMED was correlated with SCIA \((r = 0.39, p \leq 0.01)\) meaning students with mothers who completed more years of education were more likely to have better attitudes toward science. Finally, DADED was negatively correlated to SAI \((r = -0.36, p \leq 0.05)\). Students with more educated fathers were more likely to have lower levels of science anxiety.

For the achievement group, GPA was correlated to SGPA \((r = 0.88, p \leq 0.01)\). This value is somewhat inflated due to science grades being part of the overall grade. Those subjects with high overall grades were more likely to have better grades in science, and those with low GPA tended to have low SGPA. TAIW was negatively correlated to both GPA and SGPA \((r = -0.37, p \leq 0.05\) and \(r = -0.38, p \leq 0.05)\). Those with high GPA and SGPA had lower levels of test anxiety worry. This is consistent with the literature. Worry, a different part of test anxiety than emotionality, was a better predictor of achievement than emotionality. Finally, SGPA was correlated with SCIA \((r = 0.39, p \leq 0.01)\). Those with higher SGPA were apt to have a positive attitude toward science and those with low SGPA were more apt to have a negative attitude toward science. It is not surprising that there is no correlation between either measures of achievement with science anxiety as the majority of the sample was science majors with low levels of science anxiety.
Summary of Results

Analysis of data from both groups yielded several patterns. Table 17 shows the summary of statistically and educationally significant findings for the total sample. Table 18 illustrates those findings unique to the achievement subsample.
Table 17

Findings for the Total Sample

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>$r_{xy}$</th>
<th>$p$</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td>MAJ</td>
<td>0.17</td>
<td>0.05</td>
<td>Girls: more likely to be science majors</td>
</tr>
<tr>
<td>GEN</td>
<td>DADED</td>
<td>-0.19</td>
<td>0.05</td>
<td>Boys have fathers with science occupations</td>
</tr>
<tr>
<td>GEN</td>
<td>SAI</td>
<td>0.24</td>
<td>0.00</td>
<td>Girls have more science anxiety</td>
</tr>
<tr>
<td>MAJ</td>
<td>SCIA</td>
<td>0.50</td>
<td>0.00</td>
<td>Science majors have positive attitudes toward science</td>
</tr>
<tr>
<td>MAJ</td>
<td>DADSCI</td>
<td>0.20</td>
<td>0.01</td>
<td>Science majors have fathers in science</td>
</tr>
<tr>
<td>MORSCI</td>
<td>SCIA</td>
<td>0.23</td>
<td>0.00</td>
<td>More science, more positive attitudes toward science</td>
</tr>
<tr>
<td>REQ</td>
<td>SCIA</td>
<td>0.21</td>
<td>0.01</td>
<td>More required, more positive attitudes toward science</td>
</tr>
<tr>
<td>OPT</td>
<td>SCIA</td>
<td>0.40</td>
<td>0.00</td>
<td>More electives, more positive attitudes toward science</td>
</tr>
<tr>
<td>OPT</td>
<td>DADSCI</td>
<td>0.21</td>
<td>0.01</td>
<td>More electives, father in science</td>
</tr>
<tr>
<td>OPT</td>
<td>DADED</td>
<td>0.17</td>
<td>0.05</td>
<td>More electives, father has more education</td>
</tr>
<tr>
<td>DADSCI</td>
<td>MOMSCI</td>
<td>0.41</td>
<td>0.00</td>
<td>Father in science, mother in science</td>
</tr>
<tr>
<td>DADSCI</td>
<td>DADED</td>
<td>0.42</td>
<td>0.00</td>
<td>Father in science, father has more education</td>
</tr>
</tbody>
</table>

(table continues)
<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>$r_{xy}$</th>
<th>$p$</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>DADSCI</td>
<td>MOMED</td>
<td>0.20</td>
<td>0.01</td>
<td>Father in science, mother has more education</td>
</tr>
<tr>
<td>DADSCI</td>
<td>REQTOT</td>
<td>0.26</td>
<td>0.00</td>
<td>Father in science, more required science depth</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>DADED</td>
<td>0.18</td>
<td>0.05</td>
<td>Mother in science, father has more education</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>MOMED</td>
<td>0.28</td>
<td>0.00</td>
<td>Mother in science, mother has more education</td>
</tr>
<tr>
<td>MOMSCI</td>
<td>REQTOT</td>
<td>0.22</td>
<td>0.01</td>
<td>Mother in science, more required science depth</td>
</tr>
<tr>
<td>DADED</td>
<td>MOMED</td>
<td>0.63</td>
<td>0.00</td>
<td>Father has more education, mother has more education</td>
</tr>
<tr>
<td>DADED</td>
<td>REQTOT</td>
<td>0.22</td>
<td>0.01</td>
<td>Father has more education, more required science depth</td>
</tr>
<tr>
<td>MOMED</td>
<td>SAI</td>
<td>-0.18</td>
<td>0.05</td>
<td>Mother has more education, less science anxiety</td>
</tr>
<tr>
<td>SCIA</td>
<td>DADSCI</td>
<td>0.26</td>
<td>0.00</td>
<td>More positive attitudes toward science, father in science</td>
</tr>
<tr>
<td>SCIA</td>
<td>TAIW</td>
<td>-0.18</td>
<td>0.05</td>
<td>More positive attitudes toward science, less worry</td>
</tr>
<tr>
<td>SCIA</td>
<td>REQTOT</td>
<td>0.40</td>
<td>0.00</td>
<td>More positive attitudes toward science, more required science depth</td>
</tr>
<tr>
<td>SCIA</td>
<td>SAI</td>
<td>-0.27</td>
<td>0.01</td>
<td>More positive attitudes toward science, less science anxiety</td>
</tr>
<tr>
<td>TAIE</td>
<td>TAIW</td>
<td>0.74</td>
<td>0.00</td>
<td>More emotionality, more worry</td>
</tr>
<tr>
<td>SAI</td>
<td>TAIW</td>
<td>0.56</td>
<td>0.00</td>
<td>More science anxiety, more worry</td>
</tr>
<tr>
<td>SAI</td>
<td>TAIE</td>
<td>0.53</td>
<td>0.00</td>
<td>More science anxiety, more emotionality</td>
</tr>
</tbody>
</table>
Table 18

Findings Unique to the Achievement Subsample

<table>
<thead>
<tr>
<th>Variable 1</th>
<th>Variable 2</th>
<th>$r_{xy}$</th>
<th>$p$</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GEN</td>
<td>REQ</td>
<td>0.34</td>
<td>0.05</td>
<td>Females to take more required science</td>
</tr>
<tr>
<td>GEN</td>
<td>TAIW</td>
<td>0.35</td>
<td>0.05</td>
<td>Females have higher levels of worry</td>
</tr>
<tr>
<td>MAJ</td>
<td>SAI</td>
<td>-0.31</td>
<td>0.05</td>
<td>Science majors have less science anxiety</td>
</tr>
<tr>
<td>OPT</td>
<td>MOMED</td>
<td>0.30</td>
<td>0.05</td>
<td>More electives, mothers have more education</td>
</tr>
<tr>
<td>DADED</td>
<td>SAI</td>
<td>-0.36</td>
<td>0.05</td>
<td>Fathers have more education, less science anxiety</td>
</tr>
<tr>
<td>MOMED</td>
<td>SCIA</td>
<td>0.39</td>
<td>0.01</td>
<td>Mothers have more education, more positive attitudes toward science</td>
</tr>
<tr>
<td>SGPA</td>
<td>GPA</td>
<td>0.88</td>
<td>0.00</td>
<td>Better science achievement, better achievement in general</td>
</tr>
<tr>
<td>SGPA</td>
<td>TAIW</td>
<td>-0.38</td>
<td>0.05</td>
<td>Better science achievement, less worry</td>
</tr>
<tr>
<td>SGPA</td>
<td>SCIA</td>
<td>0.39</td>
<td>0.01</td>
<td>Better science achievement, more positive attitudes toward science</td>
</tr>
<tr>
<td>TAIW</td>
<td>GPA</td>
<td>-0.37</td>
<td>0.05</td>
<td>Less worry, better achievement</td>
</tr>
</tbody>
</table>
CHAPTER 5

CONCLUSIONS

In this investigative study, an attempt was made to learn if or how several variables 1) correlated with science anxiety and 2) could produce a regression model to describe science anxiety. The variables were determined from the literature to be involved either directly or indirectly with science anxiety. These included gender, course of study (including major, and involvement in science measured by required and elective courses taken and to be taken), parent background (measured by father's and mother's occupation and level of education), attitude toward science, the test anxiety components of worry and emotionality, and achievement (measured by GPA and SGPA).

Results Summary of the Correlational Study - Total Sample

The correlations for gender and any other variable in this study were with major, father's level of education, and science anxiety. There were more females as science majors than males. Fathers of males have more education. Finally, females
have more science anxiety than males. This result is in agreement with the literature, thus adding to its substantiation.

There were quite a few relationships found in the course of study category. Science majors tend to take more science courses (non-science majors tend to avoid taking science courses), have more positive attitudes toward science, and tend to have fathers in science related occupations. Those students who take more science courses plan to take both required and elective courses. They also have more positive attitudes toward science. Students who plan to take more elective courses are likely to have fathers in science occupations with higher levels of education.

Parent background results are interrelated. Students having parents with science related occupations had taken more science courses than students having parents with non-science related occupations. Fathers with science related occupations tend to have had more education. The same is true for mothers. Also, students who had mothers with higher levels of education were less apt to be anxious about science. Here, as with the literature, parents who value education and whose careers tend to involve science may instill these values and interests in their children. High value for education may mean higher respect for study and learning, and with that comes lower levels of anxiety. In this case, that meant lower levels of science anxiety.

The attitude toward science variable indicated several relationships. As previous research showed, science majors were more likely to have positive attitudes toward science than non-science majors. Those with positive science attitudes took and planned to take more required science courses, thus indicating a greater
involvement in science. This positive attitude toward science is also associated with fathers having science related occupations. Those with positive attitudes toward science were more likely to have less worry about tests and less science anxiety. It is not known whether positive attitudes toward science reduce science anxiety, or whether low levels of science anxiety result in more positive attitudes, however the first scenario seems more likely. It seems logical that a student must have an opinion about science before they know if they are anxious about it.

Finally, test anxiety and its components worry and emotionality, correlated moderately with each other and with science anxiety. The greater the emotionality, the greater level of test worry. Those with high levels of test anxiety worry or emotionality had high levels of science anxiety.

There is an overall picture that can be seen when all the relationships are taken into consideration. Science majors tend toward having more positive attitudes toward science, and they tend to take and plan to take more science courses indicating a greater involvement in science. This involvement may be due to their positive attitude. Those students who take more science courses, perhaps influenced by their parents' educational and occupational values and interests, are also more likely to have positive attitudes toward science. Those with positive attitudes toward science have lower levels of science anxiety.

Results Summary of the Multiple Linear Regression Analysis – Total Sample

The full regression, that is, regression involving all variables, resulted in an $R^2$ of 0.47. All variables in combination can explain 47% of the variability in science
anxiety with this sample. Was there a better model(s) that could describe science anxiety more completely? When the stepwise regression was complete, variables not significant at the \( p < 0.05 \) level were not considered. That left five variables - test anxiety worry (TAIW), mother's level of education (MOMED), test anxiety emotionality (TAIE), attitude toward science (SCIA), and gender (GEN). This is not surprising because these variables were among those most highly correlated either directly or indirectly with science anxiety. After all these variables were entered, one step at a time, the final step resulted in an \( R^2 \) of 0.44, which was very close to the \( R^2 \) with all variables.

Figure 3 is a preliminary path diagram and shows the variables and their standardized betas for science anxiety and the variables from the stepwise linear regression analysis. Comparing this diagram to the hypothesized model (Figure 1), there are fewer connections between science anxiety and the predictor variables. This would in part be due to the fact that the variables not included in the "best" set of predictors do not explain variance not already accounted for by the "best" set. Parents career interests and education appear to influence students attitudes toward science. This attitude influences and is influenced by choice to major in science related courses of study and opting to take elective science courses. The gender, mother's education, attitudes toward science, and test anxiety are direct predictors of science anxiety.
Figure 3. Summary of the linear regression analysis coefficients for the variables GEN, MAJ, OPT, MOMED, DADSCI, TAIW, TAIE, SCIA, and SAI - Total Sample
Three other linear regression analyses were made. These were the stepwise regressions using test anxiety worry (TAIW), test anxiety emotionality (TAIE), and attitude toward science (SCIA) separately as the dependent variables. No predictor \( p \leq 0.05 \) variables were found for either the worry or emotionality variables. However, three variables comprised a set of significant predictors of attitude toward science. Major (MAJ) accounted for 25% of the variance in attitude toward science. More elective courses (OPT) and father's occupation, science related or not (DADSCI) were the other two variables. In combination, these three variables accounted for 32% of the variance of attitude toward science. Figure 4 is a path diagram focusing on these variables which are related to attitude toward science.
Figure 4. Summary of the linear regression analysis coefficients for the variables MAJ, OPT, DADSCI, and SCIA - Total Sample
Results Summary of the Correlational Study - Achievement Subsample

There were some differences in the patterns of correlations in this subsample compared with the total sample. One major difference was a homogeneity regarding majors. Most of this subsample were science majors, while the total sample was about half science majors and half non-science majors.

Regarding the gender variable, females planned to take more required courses, but also had higher levels of test anxiety worry. Science majors had less science anxiety, however, the homogeneity problem may have had some influence here. Students who planned to take elective science courses tended to have mothers with higher levels of education.

Parent influence, especially that of education, was seen in other correlations as well. Students with fathers with higher levels of education were less likely to be anxious about science. Those with mothers having more education tended to take more elective courses and were more likely to have positive attitudes toward science.

There are, of course, differences in patterns simply because another variable was added for this group - achievement. First, GPA and SGPA were highly correlated. This is due in part to the fact that the SGPA is a subset of the grades included in the GPA. Those students who had higher grades overall were more likely to have better grades in science. Those with lower grades overall had lower grades in science. SGPA was also correlated with test anxiety worry. The higher the worry level, the poorer the science grades. Finally, SGPA was related to attitude toward science.
In summary, science majors tend to take more science courses, but are not as likely to take elective science courses. Parent background related to higher level of education corresponds to more positive attitudes toward science. High achievement in science and positive attitudes toward science are related. Achievement is not correlated to emotionality or science anxiety, but it is related to worry about tests. This finding further substantiates what past research has said. Worry is a better predictor of achievement than emotionality. However, achievement may have an indirect effect on science anxiety. High achievement relates to positive attitudes toward science. Positive attitudes toward science is correlated to low levels of science anxiety. Therefore, indirectly, high achievement relates to low science anxiety.

Conclusions

The study of science anxiety is an important undertaking because of its possible relationships to at least two areas of interest in science education. Those two areas are achievement and attitude. This study in particular, had the exploratory objective of trying to determine those variables that are related to or effect science anxiety with the hopes to better understand science anxiety. If science anxiety indeed is related to achievement and attitude, a better understanding of science anxiety may help to avoid negative consequences it may have.

One objective of this study was to identify variables that tend to have significant relationships with science anxiety across samples. These variables are test anxiety worry and emotionality, parent background (best represented by mothers level
of education), attitude toward science (which had significant relationships with elective courses to be taken, choice of major, and fathers with science related occupations), and gender.

These five variables best represent the groups of variables related either directly or indirectly to science anxiety. The main points discerned from the study follow, as well as an interpretation of the findings, with brief explanations of possible courses of action in practice and/or research. More detailed descriptions of these practice and research endeavors follows in the last section (Future Research with Implications for Practice).

One important component of science anxiety is test anxiety. Those who had high levels of test anxiety were likely to have high levels of science anxiety as well. What does this show? This indicates that perhaps part of science anxiety is test anxiety. Recall science majors were less science anxious than non-science majors. These students did, however, have some levels of test anxiety. Perhaps they are anxious mainly with what grade they will receive in a science course, and this fear could be compounded if they have to take several more science courses. With the non-science majors their science anxiety was more than just test anxiety. The additional anxiety may have come from other sources such as those stated earlier about gender bias, and the propagation of parent science anxiety. It seems further examination of this relationship between test anxiety and science anxiety should focus on how to reduce test anxiety. For example, different students with different learning styles may feel comfortable with different testing situations and formats. Determining
these preferences and utilizing varied testing styles may be the key to reducing test anxiety.

Those with better attitudes toward science have lower science anxiety. This is true for majors and non-majors, females and males, those with parents having science or non-science related occupations, and so on. One of the goals of science education and science educators should be to improve attitudes toward science. Once again, this is not meant to say that all students need to become scientists or have science related occupations. All students, and all people for that matter, need to be more aware of science and its relevance to their lives in this technological world in which they live. There is no place for negative attitudes toward science or science anxiety. That only leads to avoidance and furthers ignorance. It seems clear from this study that attitude toward science and science anxiety are indeed related. To improve the first, we must decrease the second. How can this be accomplished? First, both genders need to be encouraged in their science experiences. But one factor that was highly related to attitude toward science was parent background. Parent attitudes toward science may need to be improved in order to improve student attitudes toward science.

Parents may influence their children and how they perceive science. This study looked specifically at parents' education level and occupation. How may these two variables affect their bias or attitudes? It seemed that parents with higher levels of education and science related occupations had positive attitudes toward science. Perhaps they valued education in general, and, due to their occupation, they understood the relevance of science and valued science education specifically. They
could transfer these values to their children, resulting in students who had positive attitudes toward science with low levels of science anxiety.

Parents who have negative attitudes and/or science anxiety themselves may not see the relevance or importance of science, and transfer those feelings to their children. Children in these households may need to become involved with programs that illustrate what they lack in the home - how science is important and can be interesting and fun. Parent attitude toward science would also need to be improved and parent science anxiety would also need to be decreased in order to improve student attitudes and decrease student science anxiety.

**Females are more science anxious than males.** Why? Are they conditioned to be so? Is there gender bias? Somehow, females develop science anxiety to a greater extent, so further study needs to focus on how to decrease science anxiety in females. Parents in the home need to be aware of any gender bias they may have and overcome it by encouraging all children, but especially the daughters. One way to encourage their children, especially daughters, is to be role models, and identify shared goals and expectations related to science. Perhaps, then, this cycle of science anxiety due to gender differences can be eliminated.

**Science majors had less science anxiety than non-science majors.** How did this pattern develop? It is possible that there was science anxiety in the home. Remember, those students whose parents had science related occupations were more likely to be science majors. This is not to say that if parents were less science anxious and more science passionate that all students would become science majors.
That is not what is desired. Not everyone can have science related occupations. What is desired is a decrease in science anxiety in non-science majors. How could this be accomplished? Further research should focus on those variables directly related to science anxiety - to decrease science anxiety, decrease test anxiety, improve attitude toward science, and encourage all students, but especially females. Examples of efforts to undertake those endeavors were illustrated above. The difference is that these efforts could be directed toward non-science majors. The choice of major should not be one of avoiding science, but one of following another interest.

Future Research With Implications for Practice

The overall picture of science anxiety and what influences it has many implications. There are several variables which seem related to science anxiety more than others either directly or indirectly. First, test anxiety and its components are correlated with science anxiety. Again, perhaps test anxiety in some situations (for example, for non-science majors) is part of, and in others (for example, for science majors) synonymous with, science anxiety. What does this mean for practice? Advocating the decrease of test anxiety might seem to be the answer, but how is this to take place?

There are several possible solutions. Future research should focus on the documentation of outcomes which result from a variety of activities and testing formats theoretically designed to reduce test anxiety. Strategies for reducing test anxiety might include: make students aware of relaxation programs which would teach relaxation techniques designed to help decrease anxiety during test taking. However,
this may only be practical at the college level where such programs may be readily available on campus.

Providing a variety of evaluation types is another possible solution. Teachers at the college level seem dependent on the exam. In-class exams may produce more test anxiety than any other method of evaluation such as a take home exam. Wherever it is practical, teachers could determine the testing type students are most comfortable with and attempt to use that testing style. If that is not possible, and in-class pen and paper tests are the only option, teachers could try and vary test question styles. For example, some students may feel more comfortable answering true/false, multiple choice, matching style questions where others prefer to write essays or short answers. If possible, a teacher could design tests with a combination of both types of questions.

Other methods of evaluation not so stressful and less conducive to test anxiety, such as oral and written reports, laboratory exercises and practicals, and class projects are just a few possible alternatives. Laboratory exercises allow students not only to learn, but also illustrate their knowledge of concepts learned in lecture or from reading texts. The advantages of learning by doing have been advocated quite recently (Doran, Boorman, Chan, & Hejaily, 1993). In addition, students working together learn from each other and help each other. This cooperation may reduce test anxiety.

Another example of an alternative to testing are class projects. An example not only illustrates one such project, but also combines learning concepts with issues so that relevance can be realized. This project involves dividing a class into small groups, and assigning each group member a role (such as government official,
businessman, scientist, and parent), and each group a contemporary scientific issue such as genetic engineering or nuclear power. The group members would then have to determine how each would deal with the issue as their role, then the group would discuss it as a community.

Attempts at designing and implementing reforms advocating such alternative assessments are being made, but any such attempts are aimed at K-12 level. An example of this attempt is the Science Standards for Assessment which is part of the National Science Education Standards (National Research Council, 1993, July). These standards actually state:

> assessment is not synonymous with tests. Rather, assessment is a process whose purpose is to provide information to individuals in the science education system on which to base decisions about student attainment and their opportunities to learn science. (p. 11)

The relevance of these standards for the college level should be studied. If decreased test anxiety contributed to more positive attitudes toward science as well as better achievement, that would be reason enough to justify such reforms.

There seemed to be a strong relationship between test anxiety and science anxiety. In fact, for science majors, it seemed as though their science anxiety was test anxiety. Therefore, research examining this relationship between test anxiety and science anxiety could be another step in understanding science anxiety. One possible approach would be to present testing situations in science classes, one inducing test anxiety, one not. For example, for the high test anxiety situation, students could be told to think of situations where the test is of great importance, is going to be very
difficult, or there will be negative consequences if they do not perform well. For the low test anxiety situation, students could be told the opposite types of scenarios - the test does not count much, it will be easy, or there will be no negative consequences if they do not perform. Then, once these situations are understood, the test anxiety levels could be measured. This would be a beginning to understand how the science test elicits test anxiety, then how that test anxiety is reflected by the science anxiety. Are there correlations between high test anxiety situations with high science anxiety?

The next area of focus should be attitude toward science and the variables that are related to it. Once again, not all students can be science majors. But they all can learn to appreciate science. Improving attitude toward science, then, may also lead to less science anxiety and improvement in science achievement. Teachers at all levels, and especially at the college level where this study took place, need to keep their clients in mind. Science majors may be there for reasons other than love of science. Non-science majors may have avoided science not from science anxiety, but from lack of interest. Science education at all levels as well as science teacher education, should take into account that there are all levels of interest as well as science anxiety in all groups.

Research and development related to making science courses relevant, not just interesting, needs to be done. One way to do this might be the group project mentioned in the previous section. Class discussions can illustrate relevance of a concept by getting students to think of and relate to the class some examples or personal experiences where the science concepts have a clear and important influence.
on matters which students care about. Interest will not keep students, especially non-science students, involved with science past a final exam. Relevance, examples of what is being studied in day to day life, could show that science is not something to be feared or avoided, but used and appreciated.

Approaches to helping students get involved with science, even if they will not be directly participating in its study as a career should be explored. An example of this could be getting students to be critical thinkers. Class discussions could center on newspaper and magazine articles or television programs. Students could determine what important aspects of these clips were, and if there was any incorrect information or missing information bringing into the discussion those concepts learned in class. By being critical thinkers, they could then use their knowledge and their critical thinking skills to become actively involved in community issues and make future decisions about other science related issues they may encounter. This process is not only an activity in critical thinking, but it could illustrate to students the importance of science awareness in everyday life. This awareness, increased by interest, may improve attitudes toward science, and ultimately decrease science anxiety. Research that documents the strategies and outcomes of such programs would be of value.

Another way of improving attitude toward science and decreasing science anxiety, especially at the college level, is to teach without science major vs non-science bias. Science majors have better attitudes toward science and non-science majors have more negative attitudes toward science. Teachers must be aware of their audience, whether or not they are science majors or not. Research which identifies
and describes such bias along with ways to alleviate such bias is needed. Teachers should not assume non-science majors need "watered down" science and decrease the complexity of the material to the point of condescension. Attitude is sure to plummet. Instead, topics should be taught at levels appropriate to the audience. For example, where biochemists may get the details of the Kreb's cycle for this detail is important to future study or research, non-science majors taking a course in nutrition may be taught the basics of the food types and metabolism and be spared the details that the biochemists are required to learn.

One factor that related to attitude toward science was that of parent background, specifically education level and occupation. Focus of research may require further study into factors that contribute to parent attitudes and values related to science and education. One outcome of this research could be parent education programs developed to help parents become more confident and more appreciative of science in their lives. The indication is that students with parents having more education and science related occupations have better attitudes toward science, which then may equate to low levels of science anxiety. It would be impractical to say parents with low education levels must go back to school or that they must change professions. What is more important is to determine what the education level and occupation imparts to the parents and how that might be transmitted to other parents and students. Those with more education and/or occupations related to science most likely have positive attitudes toward science and low science anxiety levels. These parents, especially those with science occupations, could be part of a partnership with
schools and become involved with school or class science projects, they could visit
classes and bring with them their experience, their enthusiasm, in short, their positive
attitudes. Those parents who have poor attitudes toward science and/or who are
science anxious themselves, need to improve them. There could be programs to
educate parents, getting them involved with science in many of the same ways
described above for example, by having them participate in discussions, laboratory
activities, and projects. These and other strategies should be developed and the
outcomes documented.

One last variable to consider is gender. It seems clear that for some reason,
females are more science anxious than males. All students should be encouraged to
learn about science, but perhaps females must be especially encouraged. Strategies for
influencing the level of science anxiety for females should be explored and outcomes
documented. Positive female role models may be one answer. Teachers could show
films with female scientists, have posters illustrating females pursuing science, and
provide reading material depicting females who have contributed to science. Parents
could point out articles or television programs that show females in science as well.

Although some relationships were determined in this study, others need to be
elucidated to get the full picture. Other attempts should be made to determine effects
of variables separately. In other words, a path analysis could determine effects of one
variable in a group without the effects of the others. Other combinations of variables
may need to be tested in future models as well. Indirect relationships were implied,
but they need to be indicated more precisely. Also, other variables not utilized in this
study such as teacher attitudes and peer influence, could be included in further research.

Finally, perhaps new instruments could be developed to further study science anxiety. This study illustrates not only the complexity of the topic, but also the interrelatedness of the variables. An attempt to study many variables at once required the combination of two published instruments and the addition of other questions to ascertain information not achieved by those two. There is only one instrument for science anxiety in existence. This instrument, though reliable in this study, it was not designed for students older than 8th grade. Statements reflecting more appropriate activities for the college level could be developed. For example, rather than “Showing your parents your science grade”, a more appropriate statement might be “Getting your grade on a final exam.” This instrument may also not provide the information required to complete the picture of science anxiety. For example, though it contains items related to test taking, and thus may help illustrate the connection with test anxiety, items reflecting attitudes toward science, parent attitude toward science, and gender differences in science could be written.

One other alternative to another science anxiety instrument would be interviews with both students and parents. In depth questions about such things as past experiences with science related activities, past experiences with science tests, opinions as to why science is or is not important, and experiences related to gender bias could be asked. Answers could provide many more details into the development of students attitudes toward science and their science anxiety.
APPENDIX A

INSTRUMENT
Test Attitude Inventory
(TAI)

Please Provide the following information:
Name ___________________________ I. D. Number _________________

Directions

A number of statements which people have used to describe themselves are given on
the following page. Read each statement and then circle the appropriate number to the
right of the statement to indicate how you generally feel:

1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Almost Always

There are no wrong or right answers. Do not spend too much time on one statement
but give the answer which seems to describe how you generally feel.

Please answer every statement.
Test Attitude Inventory

1 = Almost Never, 2 = Sometimes, 3 = Often, 4 = Almost Always

1. I feel confident and relaxed while taking tests. 1 2 3 4
2. While taking examinations I have an uneasy, upset feeling. 1 2 3 4
3. Thinking about my grade in a course interferes with my work on tests. 1 2 3 4
4. I freeze up on important exams. 1 2 3 4
5. During exams I find myself thinking about whether I'll get through school. 1 2 3 4
6. The harder I work at taking a test, the more confused I get. 1 2 3 4
7. Thoughts of doing poorly interfere with my concentration on tests. 1 2 3 4
8. I feel very jittery when taking an important test. 1 2 3 4
9. Even when I'm well prepared for a test, I feel very nervous about it. 1 2 3 4
10. I start feeling very uneasy just before getting a test paper back. 1 2 3 4
11. During tests I feel very tense. 1 2 3 4
12. I wish examinations did not bother me so much. 1 2 3 4
13. During important tests I am so tense that my stomach gets upset. 1 2 3 4
14. I seem to defeat myself while working on important tests. 1 2 3 4
15. I feel very panicky when I take an important test. 1 2 3 4
16. I worry a great deal before taking an important examination. 1 2 3 4
17. During tests I find myself thinking about the consequences of failing. 1 2 3 4
18. I feel my heart beating very fast during important tests. 1 2 3 4
19. After an exam is over I try to stop worrying about it, but I can't. 1 2 3 4
20. During examinations I get so nervous that I forget facts I really know. 1 2 3 4

132
Science Attitude Inventory
(SAI)

Please provide the following information:

Name: ___________________________  I.D. Number ________________

The statements in this questionnaire are about science and science related experiences. For each statement, place an X on the line under the column that best describes how you would feel in that situation.

Example:

<table>
<thead>
<tr>
<th>Very Calm</th>
<th>Fairly Calm</th>
<th>Neutral</th>
<th>A Little Nervous</th>
<th>Very Nervous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

(If giving an oral book report makes you nervous only a little amount, you would place an X on "A Little Nervous.")

<table>
<thead>
<tr>
<th>Very Calm</th>
<th>Fairly Calm</th>
<th>Neutral</th>
<th>A Little Nervous</th>
<th>Very Nervous</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

1. Starting science class.
   |             |         |                  | X            |             |

2. Having someone watch you do an experiment.
   |             |         |                  | X            |             |

3. Studying for a test in science.
   |             |         |                  | X            |             |

4. Planning a well-balanced meal to pack for lunch.
   |             |         |                  | X            |             |

5. Looking through the science book for your class.
   |             |         |                  | X            |             |

6. Mixing boiling water and ice to get water to reach the right temperature for an experiment.
<p>|             |         |                  | X            |             |</p>
<table>
<thead>
<tr>
<th></th>
<th>Very Calm</th>
<th>Fairly Calm</th>
<th>Neutral</th>
<th>A Little Nervous</th>
<th>Very Nervous</th>
</tr>
</thead>
<tbody>
<tr>
<td>7.</td>
<td>Studying for a test about the earth.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.</td>
<td>Visiting a science museum.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Being asked to explain a topic in science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Using a thermometer to measure the temperature of water in an experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Taking a science test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Measuring a cup of sugar to make cookies.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Being called on in science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14.</td>
<td>Showing a classmate the results of your experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15.</td>
<td>Taking a quiz in science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16.</td>
<td>Cooling down a hot sink of water to the right temperature to be able to wash dishes.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.</td>
<td>Asking the teacher a question in science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18.</td>
<td>Weighing something to use in an experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Calm</td>
<td>Fairly Calm</td>
<td>Neutral</td>
<td>A Little Nervous</td>
<td>Very Nervous</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>-------------</td>
<td>---------</td>
<td>------------------</td>
<td>--------------</td>
</tr>
<tr>
<td>19. Memorizing the names of parts of the body for a science test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Lighting a grill for a barbecue.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Doing a science homework assignment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Figuring out how to connect a light bulb in an electrical experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Memorizing the names of things in space for a science test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Following the steps to build a model.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Listening to the teacher in science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Adding a small amount of powder to a liquid in an experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Showing your parents your last science test.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Reading a science magazine and having a friend ask you about it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Writing a report for science class.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30. Following directions to do an experiment.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very Calm</td>
<td>Fairly Calm</td>
<td>Neutral</td>
<td>A Little Nervous</td>
<td>Very Nervous</td>
</tr>
<tr>
<td>---</td>
<td>-----------</td>
<td>-------------</td>
<td>---------</td>
<td>-----------------</td>
<td>-------------</td>
</tr>
<tr>
<td>31. Showing your parents your science grade.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. Focusing a camera to take a picture.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. Having a classmate listen to your science report.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. Focusing a microscope.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Thinking about a test in science one day before you are to take it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>36. Replacing a dead bulb in a lamp.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>37. Reading a chapter in your science book and being asked to explain it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>38. Blowing up a balloon to the right size for a science experiment on air.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39. Thinking about a science test one hour before you are to take it.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40. Filling your bicycle tire with the right amount of air.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Name ___________________________ I.D. Number __________________

1. Please check the appropriate choice. Male ____ Female ____

Refer to the course list for the next two questions.

2. What REQUIRED science courses have you take since high school? Check R at the appropriate courses. If there are others, use this space. __________________________________________________________

3. What ELECTIVE science courses have you taken since high school? Check E at the appropriate courses. If there are others, use this space. __________________________________________________________

4. Do you plan to take more science classes: ____ If yes, will they be required, elective, both? ____

5. What is your major and minor (if you have one)? _______________________

6. For the following statements, please indicate your choice by entering the appropriate number.

Strongly Disagree (1) Disagree (2) Neutral (3) Agree (4) Strongly Agree (5)

I like to learn about science ____

I do not enjoy science ____

I think science is interesting ____

Science is not important ____

7. What is your father's occupation? _____________________________

8. What is your mother's occupation? _____________________________

9. For each parent, please check the appropriate choice concerning level of school completed.

Father: 

Less than High School (K-12) ____ High School or GED ____

Associate's Degree (2yr) ____ Bachelor's Degree (4yr) ____

Master's Degree ____ Doctorate/Professional Degree ____

Mother: 

Less than High School (K-12) ____ High School or GED ____

Associate's Degree (2yr) ____ Bachelor's Degree (4yr) ____

Master's Degree ____ Doctorate/Professional Degree ____

137
<table>
<thead>
<tr>
<th>Course List</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>R = REQUIRED</strong></td>
</tr>
<tr>
<td>Agronomy 200</td>
</tr>
<tr>
<td>An. Sci. 310</td>
</tr>
<tr>
<td>Anthrop. 200</td>
</tr>
<tr>
<td>Astron. 161</td>
</tr>
<tr>
<td>Astron. 162</td>
</tr>
<tr>
<td>Biochem. 511</td>
</tr>
<tr>
<td>Biochem. 512</td>
</tr>
<tr>
<td>Biochem. 521</td>
</tr>
<tr>
<td>Biochem. H521</td>
</tr>
<tr>
<td>Biochem. 613</td>
</tr>
<tr>
<td>Biochem. 614</td>
</tr>
<tr>
<td>Biochem. 615</td>
</tr>
<tr>
<td>Biology 101</td>
</tr>
<tr>
<td>Biology 102</td>
</tr>
<tr>
<td>Biology 113</td>
</tr>
<tr>
<td>Biology 114</td>
</tr>
<tr>
<td>Chem. 101</td>
</tr>
<tr>
<td>Chem. 102</td>
</tr>
<tr>
<td>Chem. 121</td>
</tr>
<tr>
<td>Chem. 122</td>
</tr>
<tr>
<td>Chem. 123</td>
</tr>
<tr>
<td>Chem. H201</td>
</tr>
<tr>
<td>Chem. H202</td>
</tr>
<tr>
<td>Chem. H203</td>
</tr>
<tr>
<td>Chem. 221</td>
</tr>
<tr>
<td>Chem. 245</td>
</tr>
<tr>
<td>Chem. 246</td>
</tr>
<tr>
<td>Chem. 251</td>
</tr>
<tr>
<td>Chem. 252</td>
</tr>
<tr>
<td>Chem. 253</td>
</tr>
<tr>
<td>Chem. 254</td>
</tr>
<tr>
<td>Chem. 255</td>
</tr>
<tr>
<td>Chem. 531</td>
</tr>
<tr>
<td>Chem. 532</td>
</tr>
<tr>
<td>Chem. 533</td>
</tr>
<tr>
<td>Dairy Sci. 310</td>
</tr>
<tr>
<td>Entom. 100</td>
</tr>
<tr>
<td>Entom. 101</td>
</tr>
<tr>
<td>Entom. 102</td>
</tr>
<tr>
<td>Entom. 500</td>
</tr>
<tr>
<td>Entom. 623</td>
</tr>
<tr>
<td>Entom. 631</td>
</tr>
<tr>
<td>Food Sci. 201</td>
</tr>
<tr>
<td>Geol. Sci. 100</td>
</tr>
<tr>
<td>Geol. Sci. 110</td>
</tr>
</tbody>
</table>

**E = ELECTIVE**

| |
|---|---|
| Plt Biol. 630 | --- |
| Plt Biol. 638 | --- |
| Plt Biol. 641 | --- |
| Plt Biol. 643 | --- |
| Plt Biol. 648 | --- |
| Peult. Sci. 310 | --- |
| Zool. 200 | --- |
| Zool. 201 | --- |
| Zool. 232 | --- |
| Zool. 235 | --- |
| Zool. 400 | --- |
| Zool. 405 | --- |
| Zool. 410 | --- |
| Zool. 413 | --- |
| Zool. 415 | --- |
| Zool. 511 | --- |
| Zool. 512 | --- |
| Zool. 514 | --- |
| Zool. 515 | --- |
| Zool. 630 | --- |
| Zool. 632 | --- |
| Zool. 633 | --- |
APPENDIX B

COURSE LIST AND PREREQUISITES
PREREQUISITE LIST

Agronomy 200 Crop Science: 1
   Biology 101 Introductory Biology 1

Animal Science 310 Principles of Animal Systems Physiology: 3
   Biology 113 Biological Sciences: Energy Transfer and Development
   Chemistry 101 Elementary Chemistry
   Animal Science 202 Introductory Animal Science

Anthropology 200 Introduction to Physical Anthropology: 1
   Biology 101 Introductory Biology

Astronomy 161 Introduction to Solar System Astronomy: 0

Astronomy 162 Introduction to Stellar, Galactic, and Extragalactic Astronomy: 1
   Astronomy 161 Introduction to Solar System Astronomy

Biochemistry 511 Introduction to Biological Chemistry: 7
   Chemistry 121 General Chemistry
   Chemistry 122 General Chemistry
   Chemistry 123 General Chemistry
   Chemistry 251 Organic Chemistry
   Chemistry 252 Organic Chemistry
   2 Quarters of Biological Sciences
Biochemistry 512 Biochemistry of Physiological Processes: 8

Biochemistry 511 Introduction to Biological Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

2 Quarters of Biological Sciences

Biochemistry 521 Introduction to Biological Chemistry Laboratory: 8

Biochemistry 511 Introduction to Biological Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

2 Quarters of Biological Sciences
Biochemistry H521 Honors Introduction to Biological Chemistry Laboratory: 9

Biochemistry 511 Introduction to Biological Chemistry
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 221 Analytical Chemistry 1
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
2 Quarters of Biological Sciences

Biochemistry 613 Biochemistry and Molecular Biology: 8

Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
Chemistry 253 Organic Chemistry
2 Quarters of Biological Sciences
Biochemistry 614 Biochemistry and Molecular Biology: 9

Biochemistry 613 Biochemistry and Molecular Biology
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
Chemistry 253 Organic Chemistry
2 Quarters of Biological Sciences

Biochemistry 615 Biochemistry and Molecular Biology: 10

Biochemistry 613 Biochemistry and Molecular Biology
Biochemistry 614 Biochemistry and Molecular Biology
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
Chemistry 253 Organic Chemistry
2 Quarters of Biological Sciences

Biology 101 Introductory Biology 1: 0

Biology 102 Introductory Biology 2: 1

Biology 101 Introductory Biology 1
Biology 113 Biological Sciences: Energy Transfer and Development: 1

Chemistry 101 Elementary Chemistry

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology: 2

Biology 113 Biological Sciences: Energy Transfer and Development

Chemistry 101 Elementary Chemistry

Biology H115 Honors Biology 1: 0

Biology H116 Honors Biology 2: 1

Biology H115 Honors Biology 1

Chemistry 101 Elementary Chemistry: 0

Chemistry 102 Elementary Chemistry: 1

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry: 0

Chemistry 122 General Chemistry: 1

Chemistry 121 General Chemistry

Chemistry 123 General Chemistry: 2

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry H201 Honors General Chemistry: 1

Mathematics 151 Calculus and Analytic Geometry

Chemistry H202 Honors General Chemistry: 2

Chemistry H201 Honors General Chemistry

Mathematics 151 Calculus and Analytic Geometry
Chemistry H203 Honors General Chemistry: 3
  Chemistry H201 Honors General Chemistry
  Chemistry H202 Honors General Chemistry
  Mathematics 151 Calculus and Analytic Geometry

Chemistry 221 Analytical Chemistry: 3
  Chemistry 121 General Chemistry
  Chemistry 122 General Chemistry
  Chemistry 123 General Chemistry

Chemistry 245 Organic Chemistry Laboratory: 4
  Chemistry 251 Organic Chemistry
  Chemistry 121 General Chemistry
  Chemistry 122 General Chemistry
  Chemistry 123 General Chemistry

Chemistry 246 Organic Chemistry Laboratory: 6
  Chemistry 245 Organic Chemistry Laboratory
  Chemistry 251 Organic Chemistry
  Chemistry 252 Organic Chemistry
  Chemistry 121 General Chemistry
  Chemistry 122 General Chemistry
  Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry: 3
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry

Chemistry 252 Organic Chemistry: 4
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry

Chemistry 253 Organic Chemistry: 5
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry

Chemistry 254 Organic Chemistry Laboratory: 4
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 255 Organic Chemistry Laboratory: 6

Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
Chemistry 254 Organic Chemistry Laboratory

Chemistry 531 Physical Chemistry: 12

Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Physics 111 General Physics: General Physics: Mechanics and Heat
Physics 112 General Physics: Electricity, Magnetism, and Light
Physics 113 General Physics: Modern Physics
Mathematics 151 Calculus and Analytic Geometry
Mathematics 152 Calculus and Analytic Geometry
Mathematics 153 Calculus and Analytic Geometry
Mathematics 254 Calculus and Analytic Geometry
Mathematics 255 Differential Equations and Their Applications
Chemistry 532 Physical Chemistry: 13

Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 531 Physical Chemistry

Physics 111 General Physics: General Physics: Mechanics and Heat
Physics 112 General Physics: Electricity, Magnetism, and Light
Physics 113 General Physics: Modern Physics

Mathematics 151 Calculus and Analytic Geometry
Mathematics 152 Calculus and Analytic Geometry
Mathematics 153 Calculus and Analytic Geometry
Mathematics 254 Calculus and Analytic Geometry
Mathematics 255 Differential Equations and Their Applications
Chemistry 533 Physical Chemistry: 14

Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 531 Physical Chemistry
Chemistry 532 Physical Chemistry

Physics 111 General Physics: General Physics: Mechanics and Heat
Physics 112 General Physics: Electricity, Magnetism, and Light
Physics 113 General Physics: Modern Physics
Mathematics 151 Calculus and Analytic Geometry
Mathematics 152 Calculus and Analytic Geometry
Mathematics 153 Calculus and Analytic Geometry
Mathematics 254 Calculus and Analytic Geometry
Mathematics 255 Differential Equations and Their Applications

Dairy Science 310 Principles of Animal Systems Physiology: 3

Dairy Science 202 Introductory Animal Science
Biology 113 Biological Sciences: Energy Transfer and Development
Chemistry 101 Elementary Chemistry

Entomology 100 Insects and Human Affairs: 0

Entomology 101 Insect Biology 1: 0
Entomology 102 Insect Biology 2: 1
   Entomology 101 Insect Biology 1

Entomology 500 General Entomology: 3
   3 Quarters in Biological Sciences

Entomology 623 Insect Morphology: 4
   Entomology 500 General Entomology
   3 Quarters in Biological Sciences

Entomology 631 Insect Physiology: 10
   Entomology 500 General Entomology
   Chemistry 121 General Chemistry
   Chemistry 122 General Chemistry
   Chemistry 123 General Chemistry
   Chemistry 251 Organic Chemistry
   Chemistry 252 Organic Chemistry
   Chemistry 254 Organic Chemistry Laboratory
   3 Quarters in Biological Sciences

Food Science 201 The Science of Food: 1
   Biology 101 Introductory Biology 1

Geological Sciences 100 Earth Systems 1: Geologic Environment: 0

Geological Sciences 110 History of Life on Earth - Global Change in the
   Biosphere: 1
   Geological Sciences 100 Earth Systems 1: Geologic Environment

150
Geological Sciences 121 Physical Geology: 0

Geological Sciences 122 Historical Geology: 1

Geological Sciences 121 Physical Geology

Geological Sciences 203 Geology and the Environment: 1

Geological Sciences 121 Physical Geology

Geological Sciences 205 Physical Geology of the Earthlike Planets: 1

Geological Sciences 121 Physical Geology

Geological Sciences 206 Physical Oceanography and Marine Geology: 1

Geological Sciences 100 Earth Systems 1: Geologic Environment

Geological Sciences 210 Energy, Mineral Resources, and Society: 1

Geological Sciences 100 Earth Systems 1: Geologic Environment

Geological Sciences 280 Introduction to Geophysics: 1

Geological Sciences 121 Physical Geology

Horticulture 300 General Plant Biology: 1

Biology 101 Introductory Biology 1

Human Nutrition and Food Management 210 The Science of Human Nutrition: 1

Biology 101 Introductory Biology 1

Microbiology 509 Basic and Practical Microbiology: 1

Biology 101 Introductory Biology 1

151
Microbiology 520 General Microbiology 1: 7

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Microbiology 521 General Microbiology 2: 9

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

Microbiology 520 General Microbiology 1
Microbiology 522 Principles of Infection and Resistance: 10

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

Microbiology 520 General Microbiology 1

Microbiology 521 General Microbiology 2
Microbiology 581 Microbial Genetics: 10

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

Microbiology 520 General Microbiology 1

Microbiology 521 General Microbiology 2
Microbiology 661 General Microbial Physiology: 12

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Biochemistry 511 Introduction to Biological Chemistry

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

Microbiology 520 General Microbiology 1

2 Quarters of Biological Sciences

Molecular Genetics 433 Comparative Embryology and Development: 1

Zoology 201
Molecular Genetics 500 General Genetics: 7

Biology 101 Introductory Biology
1 Quarter in Biological Sciences
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry

Molecular Genetics 501 Genetics and Molecular Biology: 8

Biochemistry 511 Introduction to Biological Chemistry
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
2 Quarters of Biological Sciences
Molecular Genetics 502 Cell Development and Biology: 9

Biochemistry 511 Introduction to Biological Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

2 Quarters of Biological Sciences

Molecular Genetics 501 Genetics and Molecular Biology
Molecular Genetics 601 Eukaryotic Molecular Genetics Laboratory: 9

Biochemistry 511 Introduction to Biological Chemistry
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
2 Quarters of Biological Sciences
Molecular Genetics 501 Genetics and Molecular Biology

Molecular Genetics 602 Eukaryotic Cell and Developmental Biology Laboratory: 10

Biochemistry 511 Introduction to Biological Chemistry
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
2 Quarters of Biological Sciences
Molecular Genetics 501 Genetics and Molecular Biology
Molecular Genetics 502 Cell and Developmental Biology

Physics 101 Nature of the Physical World: 0
Physics 102 Nature of the Physical World: 1

Physics 101 Nature of the Physical World

Physics 103 The World of Energy 1: 0

Physics 104 The World of Energy 2: 1

Physics 103 The World of Energy 1

Physics 111 General Physics: Mechanics and Heat: 0

Physics 112 General Physics: Electricity, Magnetism, and Light: 1

Physics 111 General Physics: Mechanics and Heat

Physics 113 General Physics: Modern Physics: 2

Physics 111 General Physics: Mechanics and Heat

Physics 112 General Physics: Electricity, Magnetism, and Light

Physics 131 Introductory Physics: Particles and Motion: 1

Mathematics 151 Calculus and Analytic Geometry

Physics 132 Introductory Physics: Electricity and Magnetism: 3

Mathematics 151 Calculus and Analytic Geometry

Mathematics 152 Calculus and Analytic Geometry

Physics 131 Introductory Physics: Particles and Motion

159
Physics 133 Introductory Physics: Thermal Physics,

Waves, and Quantum Physics: 5
Mathematics 151 Calculus and Analytic Geometry
Mathematics 152 Calculus and Analytic Geometry
Mathematics 153 Calculus and Analytic Geometry
Physics 131 Introductory Physics: Particles and Motion
Physics 132 Introductory Physics: Electricity and Magnetism

Physics 201 Physics by Inquiry: Matter and Heat: 0

Physics 202 Physics by Inquiry: Electricity, Magnetism, and Light: 0

Physics 367 Uses of Science in Solving Problems of Society: 1

1 Quarter in 100 level Astronomy, Biological Science, Chemistry, Geological Science, or Physics

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment: 0

Plant Biology 102 Introduction to Plant Biology 2: Plants, People, and the Environment: 1

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

160
Plant Biology 201 Introduction to Plant Evolution: 2

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

Plant Biology 102 Introduction to Plant Biology 2: Plants, People, and the Environment

Plant Biology 202 Plant Development: 1

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

Plant Biology 203 Plant Functions in the Environment: 1

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

Plant Biology 210 Local Flora: 1

Plant Biology 102 Introduction to Plant Biology 2: Plants, People, and the Environment

Plant Biology 300 General Plant Biology: 1

Biology 101 Introductory Biology 1

Plant Biology 413 Introduction to Ecology: 1

Zoology 413 Introduction to Ecology

Plant Biology 436 Introductory Plant Physiology: 3

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

2 Quarters in Chemistry
Plant Biology 502 Economic Botany: 1

1 Quarter in Biological Sciences

Plant Biology 630 Plant Physiology: 6

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry

Plant Biology 638 Morphology of Vascular Plants: 4

Plant Biology 102 Introduction to Plant Biology 2: Plants, People, and the Environment

3 Quarters in Biological Sciences

Plant Biology 641 Morphology of Angiosperms: 4

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

3 Quarters in Biological Sciences

Plant Biology 643 Plant Anatomy: 3

Plant Biology 101 Introduction to Plant Biology 1: Plants, People, and the Environment

2 Quarters in Biological Sciences
Plant Biology 648 Plant Cell Structure and Function: 9

Plant Biology 635 Plant Biochemistry
Biochemistry 511 Introduction to Biological Chemistry
Chemistry 121 General Chemistry
Chemistry 122 General Chemistry
Chemistry 123 General Chemistry
Chemistry 251 Organic Chemistry
Chemistry 252 Organic Chemistry
2 Quarters of Biological Sciences

Poultry Science 310 Principles of Animal Systems Physiology: 3

Animal Science 202 Introductory Animal Science
Biology 113 Biological Sciences: Energy Transfer and Development
Chemistry 101 Elementary Chemistry

Zoology 232 Introductory Physiology: 2

Biology 101 Introductory Biology 1
Biology 102 Introductory Biology 2

Zoology 235 Introductory Anatomy: 2

Biology 101 Introductory Biology 1
Biology 102 Introductory Biology 2
Zoology 400 Evolution: 3

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Zoology 405 Animal Diversity and Systematics: 4

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Zoology 400 Evolution

Zoology 410 Animal Form and Function: 6

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Physics 111 General Physics: Mechanics and Heat

Zoology 413 Introduction to Ecology: 2

2 Quarters in Biological Sciences
Zoology 415 Principles of Animal Cellular and Developmental Biology: 11

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Chemistry 123 General Chemistry

Chemistry 251 Organic Chemistry

Chemistry 252 Organic Chemistry

Physics 111 General Physics: Mechanics and Heat

Physics 112 General Physics: Electricity, Magnetism, and Light

Zoology 400 Evolution

Zoology 512 Laboratory in Vertebrate Dissection: 7

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Physics 111 General Physics: Mechanics and Heat

Zoology 410 Animal Form and Function

165
Zoology 514 Laboratory in Animal Physiology: 7

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Physics 111 General Physics: Mechanics and Heat

Zoology 410 Animal Form and Function

Zoology 630 Vertebrate Histology: 7

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Physics 111 General Physics: Mechanics and Heat

Zoology 410 Animal Form and Function
Zoology 632 Neurobiology: 7

Biology 113 Biological Sciences: Energy Transfer and Development

Biology 114 Biological Sciences: Form, Function, Diversity, and Ecology

Chemistry 101 Elementary Chemistry

Chemistry 121 General Chemistry

Chemistry 122 General Chemistry

Physics 111 General Physics: Mechanics and Heat

Zoology 410 Animal Form and Function
APPENDIX C

LIST OF OCCUPATIONS
1. Professional

Accountant
Architect
Computer Programmer/Analyst
Lawyer
Librarian
Religious
Social Science/Social Work
Teachers - Non science
Writers

2. Science Related

Engineers
Life/Physical Scientists
Physician/Health Services
Teacher - Science

3. Manager/Administration

Bank Officer
Buyers
Credit Personnel
Inspectors
Public Administrator

4. Sales

Ad/Salesman
Businessman
Auctioneer
Insurance Underwriter
Stock Broker

5. Clerical

Bank Teller
Clerk
Cashier
Bookkeeper
Collector
Mail Carrier
Receptionist/Secretary
6. Craftsmen
   Auto Repair
   Baker
   Construction
   Decorator
   Cable man
   Metal Craftsman
   Miller
   Optician
   Printer
   Tailor
   Telephone Lineman

9. Private Household
   Child Care
   Cook
   Housekeeper
   Laundry
   Maid/Service

7. Farming

8. Service
   Cleaning
   Food Service
   Personal Service
   Protective/Security
     Firemen, Police, Guards
   Housewife
Dear Student,

My name is Carol Hensley. I was the Ph.D. student for whom you completed the Science/Test Attitude Questionnaire earlier this quarter. Again, I must once ask for your help. One variable important to my research is that of achievement and how it relates to the attitudes. The measure of achievement required is grade point average information. In order to receive that information, I need your signed permission. Again, I will state the data in this study will be completely anonymous. In no way will your name, grades, or any other information specifically about you will be reported, only statistics. Thank you, and I appreciate your cooperation in this research.

(Student permission signature)

(Date)
LIST OF REFERENCES


