THE FEAR OF SCIENCE:

A STUDY OF SCIENCE ANXIETY AND THE LEARNING CAPABILITIES OF ADULT COLLEGE STUDENTS

by

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ABSTRACT

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One of the most challenging things a professor of science in a college setting deals with is the apprehension of students toward the very idea of science and scientists. This feeling of science anxiety does not appear to be limited by nation or culture and is often spread across all ages of students. The concept of "science is hard" is widespread and constant for many students entering a science course. This is quickly becoming a critical issue in education during a time in our world when we need to increase the numbers of well-qualified scientists. In a world where technological and scientific advancement is critical for modern life, having students who fear the very basis of modern living undermines their ability to work in the world as a whole. In an effort to understand and circumvent science anxiety, this research utilized interviews and qualitative analysis in order to determine how students dealt with science anxiety, and how it affected their learning. As a qualitative study, this research focused more on the attitudes of the students toward science than the achievement in terms of grades. This research focused on science anxiety and how it affected adult learning at the college level.

Keywords: Science anxiety, Fear, Adult Education, Qualitative Research, Adult Learning.

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Chapter 1: Introduction

In modern society, many people appear to fear science and scientific thought. This can even be seen on children's programming, such as *Pinky Dinky Doo*, where a character states "Isn't science hard?" (Sesame Workshop, 2009). To many people, the subject of science causes almost as much fear as speaking in public. In fact, by the time an adult attempts to get an education in science, anxiety typically emerges. Often this arises from the social settings, culture and educational backgrounds of learners. Both the social and cultural belief that "science is hard" is re-enforced by the media (Tobias, 1990, 1992; Tobias & Tomizuka, 1992), making education in these areas extremely challenging, especially for adult learners. Science anxiety is difficult for an educator to overcome (Bui & Alfaro, 2011; Merriam, Caffarella, & Baumgartner, 2007; Tobias, 1990), mainly because it is poorly understood and not well studied. With this sort of challenge, especially with adult learners, it becomes critical to find ways to understand this anxiety of science.

Anxiety as a whole is typically defined as a diffuse apprehension, something vague and broadly encompassing many feelings, while a fear is a reaction to a specific danger (Usera, 1984). Fears can be targeted and treated, while anxieties are much more nebulous and are often a whole collection of different fears blending together. While science anxiety is more specific in what the feeling it is aimed at (i.e., science), the emotions themselves remain muddled, making direct treatment of this type of anxiety more challenging.

Anxiety makes education in the sciences challenging, especially at collegiate levels and among adult learners. By this point in time, certain biases that are difficult to change have been set in place by culture and the surrounding society. Why these specific biases exist mainly for science and mathematics education is unknown, but many theories suggest a combination of factors such as elitism by early universities to remove those they deemed unfit for this kind of thought and cultural fears of those seen as being too clever or more intelligent than the rest of a group (Daston, 1998; Orchard, 1997). With this sort of challenge, especially with adult learners, it becomes necessary to find ways to overcome this fear of science especially in a world that relies increasingly on scientific thought and progress in many fields.

Problem Statement

With expanding technologies, both academically and globally, the world has a high need for scientists in all fields in order to maintain and increase our current standards of living. However, the number of new scientists has not increased, and it appears that one of the root causes for this may be science anxiety. In fact, students are leaving college-level science education for other areas of study (Barns, 2010; Bui & Alfaro, 2011; Dennett, 2003; Hinds, 1999; Tobias, 1990), leading to a shortage of future innovators in scientific fields such as medicine or computer technology. As a result, medical research may suffer, computer technology may falter, and much of what makes up the modern world could deteriorate. Science is a critical aspect of our lives and allows us to better understand our world and our place in it. Therefore, it is imperative to understand these emotional barriers toward science education and how it affects learning in adults.

The problem of students having science anxiety is one of the driving factors of the abdication of science programs globally. This is an issue that is well recognized in educational arenas, where often special attention needs to be paid to science education, especially with adult learners, in order for students to complete science courses for degrees (Hinds, 1999). While much research has been done on students in the United States, this is a recognized global issue as even the perceptions of science suffers in part due to cultural and social media (Daston, 1998; Epstein & Miller, 2011; Hong & Lin-Siegler, 2012; Kitzinger, 2010; Koren & Bar, 2009; Otero, Leon, & Graesser, 2002). Hinds (1999) contends that much of current science education is delivered in ways that add to student apprehension. This idea is supported by the research that shows the loss of science students globally at college academic levels (Barns, 2010; Bui & Alfaro, 2011; Dennett, 2003; Hinds, 1999; Tobias, 1990). In addition, scientific research relies on strong background knowledge of the material of the field being studied. Without proper education and training, we have ever-shrinking pools of researchers who are properly trained to work in the world today (Gates, 2010; Tobias, 1990). Finally, the lack of current information on the emotional states of students in science and their long-term effects is a serious problem that has not been studied since 1996 by Tobias. This is another reason to research science anxiety in depth.

As a global example, research has shown that performance on international math and science assessments directly relates to national growth rates (Gates, 2010; Hanushek, 2006). For example, the United States is ranked 29th out of 37 participating countries in the Program for International Student Assessment (PISA) while Germany is ranked 16th. Hanushek (2006) states that if we could move American achievement values up to match those of the middle values of the European countries, such as Germany, we could easily increase national growth by one half of one percent. A one-half of one percent increase would result in a $2,000 increase in personal per capita growth.

This is not to say that PISA measurements are the only way to measure student achievement or national growth. What works in one country academically may not be easily replicated elsewhere due to cultural and societal influences (Turgut, 2013). A country that scores high on PISA measurements may have done so because of certain cultural norms that cannot be replicated elsewhere, which would mean the economic growth of a country should not be tied to PISA scores alone (Targut, 2013). However, without science or scientists to drive innovations in research and development, some nations may suffer. Scientific innovations have the potential to improve the quality of life for many people.

In Africa, it is predicted that by 2020 one in five individuals will be carriers of HIV, if not showing signs of fully developed AIDS (Black, 2008; Tuthill, Chan, & Butler, 2014). One of the biggest challenges in dealing with this epidemic is the lack of health workers, researchers and educators willing or properly trained to help people (Black, 2008; Tuthill et al., 2014). This is especially disheartening when such incredible research is currently being done with HIV including the possibility of a cure (Micci, McGary, & Paiardini, 2015; Zhu et al., 2014).

An additional problem is that many in our nation's science and engineering workforce are heading toward retirement, and nations are not producing enough skilled workers to fill their spots ("U.S. science in crisis," 2005; "DHS report," 2008; Gates, 2010; Hanushek, 2006). The Department of Homeland Security (DHS) warned that the U.S. workforce is in crisis and our country may slip from a first world economy unless we can bolster science and math education ("DHS report," 2008). The numbers support this statement, showing that the United States now ranks in the bottom half of participating countries in terms of standardized testing on science, mathematics and reading (Hanushek, 2006). The DHS contends that current students are leaving science and math programs mainly because they find the subject matter too difficult and the payoff for earning degrees in those fields is either too distant or not enough for the effort (Kyle, 2005).

Obviously, the United States is not alone in this problem. Most current United States research is produced by foreign researchers, as shown by statistics from the National Science Board (NSB). This study showed that in 2003, 38% of doctorates in science and engineering were earned by foreign students (Zakaria, 2004). This shows a two-fold problem: foreign students come to the United States for a world-renowned education in science, but they do not return to their homelands. This deprives their home countries of scientific innovation and advancement they likely need. The other issue demonstrated here is the lack of American students entering scientific fields. For example, in 2000 there were 385 computer science majors at MIT, but the figure dropped to 240 in less than four years (Zakaria, 2004). This may be because United States students have more options available to them in terms of career choices, as scientific research areas among other careers expand; however, as fewer students enter scientific fields such as computer science or are motivated to look elsewhere, the innovation in those areas potentially decreases.

With dwindling enrollments, the level of knowledge in these areas also begins to drop, which can greatly affect future research and innovation. The NSB reported (from two international assessments based on standardized testing that focus on science, math, and reading from participating nations) that in 2004, that the United States ranked 17th among nations polled for students majoring in science and engineering. By 2006, the United States had slipped to 19th, and current rankings place the United States at 27^{th} among the 39 participating countries (Hanushek, 2006; Zakaria, 2004). Compare those values to the ranking of the United States as third among nations polled for students majoring in science and engineering in 1975 (Gates, 2010; Zakaria, 2004). Without scientists to drive innovations for future research, our world will slowly grind to a halt in terms of advancement in almost all areas.

Another issue is how educators treat the subject of science. In this case, science is defined as the "hard sciences" such as chemistry, geology, and physics. While the deans of many colleges suggest that science should be a primary focus in education, most of the time science is treated as a "second-tier" subject, and most educators feel ill-prepared to teach it in schools (Epstein & Miller, 2011; Kren, 2005; Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012). In fact, unlike the classic core subjects in elementary school education (reading, writing, mathematics), science is rarely taught every day, and quite often is simply passed over (Hanushek, 2006; Kren, 2005; Milner et al., 2012; Tobias, 1990).

Some blame the No Child Left Behind (NCLB) Act for causing some of these problems (Milner et al., 2012; Rycik, 2007). As schools struggled to meet the expectations of the Act, they took time away from non-required subjects, like science, to focus solely on those needed to meet the standards, such as reading and math scores. As reported by elementary school teachers, science was deemed a secondary subject at the initial startup of NCLB, and less classroom time was dedicated to teaching science. (Epstein & Miller, 2011; Milner et al., 2012; Rycik, 2007). This, in turn, has led to a lack of preparation of students to enter higher levels of science education (Milner et al., 2012; Rycik, 2007,) and, in many cases, potential anxiety over the material.

Currently in the United States, multiple programs designed to foster science, engineering, technology, and math (STEM) are being proposed all over the country. These programs exist within the K-12 system and into college levels. The intent is to attract more students into STEM areas. Before STEM programs were proposed, previous recruitment drives to attract students into the sciences existed. For example, in the 1950's and 60's after the launch of sputnik, the space race attracted students to science fields ("NIH Science Education Nation," n.d.). While many programs both past and present are designed to help scientific research or STEM, the fundamental problem often comes down to how science is perceived by educators and students (Epstein & Miller, 2011). In fact, about 42% of science educators in grades K through 12 are not even certified to be teaching the subject material ("National Science Board Statistics," 2006). If the educators themselves are not properly trained, how can we expect students to enroll in science courses, let alone be well prepared?

In higher education, students are leaving science and mathematics courses at all levels of education (Barns, 2010; Daston, 1998; Tobias, 1990). Between 1966 and 1988, the proportion of college freshmen planning to major in science has dropped by half (Tobias, 1990). In fact, a third to a half of all students planning to major in science end up dropping the major well into the academic process, some even after completing their initial degree (Tobias, 1990). The ironic thing is that in many cases, students feel optimistic about science in general, but they still feel constant levels of anxiety when dealing with the subject material (Bui & Alfaro, 2011; George, 2003). Even those students classified as "traditional science majors" show signs of extreme anxiety as shown by measurements using the Statistical Anxiety Rating Scale (STARS) and the Test of Science Related Attitudes (TOSRA: Fraser, 1981; Bui & Alfaro, 2011).

In many cases, some of this anxiety can be blamed on how introductory science courses for colleges are often competitive, selective and, in many cases, intimidating for students (Tobias, 1990). This intimidation seems to stem from the idea that scientists are "born, not made" and non-science majors simply would not be able to stand up to the stress of a science course. This feeling is on top of the common idea that science courses are often used to weed out less able students as a whole (Tobias, 1990). This idea was borne out of a NASA study performed between 1962 and 1969, where over 80% of the 4,000 Ph.D. scientists and engineers decided on science as a major prior to high school, based on the intrinsic interest in science alone and that teachers (high school and college) mattered little (Tobias, 1990). Moreover, less than a third of subjects named any teacher significant to their study of science, and their studies started when they were young and were intense and private. This of course leads to the idea that science can only be studied by certain "types" of people, leaving many potential students shut out in their own misconceptions of the subject (Tobias, 1990).

In a study performed in Israel using 125 high school students of both genders, it was found that most students in this age range were either ambivalent or outright concerned about scientists and science based off of models from both current media and classical literature (Koren & Bar, 2009). Of course, the image of Frankenstein was used, primarily in the film form, but discussion of *Dr. Faustus*, and the works of Swift (*Gulliver's Travels*) were also used as models for discussion. Modern works used included *The Microbe Hunters* and even in that case the image of the scientist was not positive in the eyes of the students.

Overall what most students took away from both modern and classical images of science and scientists were either ambivalent or negative with the words uncaring, nerd, anti-social, unethical, and emotionless used often to describe scientists or science in general (Koren & Bar, 2009). This is a bleak outlook by students, and it shines another light onto why most people seem to fear science education as a whole. All of these external factors lead to science anxiety and it is the job of educators to understand how this emotional issue affects learning in students.

It is the job of science educators to try to motivate students and overcome the fear of the material, but with students entering science courses already pre-disposed to fear due to poor preparation by prior educators, social stigma and cultural indoctrination, science education then becomes an uphill struggle. Hinds (1999) suggests that science educators need to "seize the moment" in a science course and address needs and fears of the students at the start. While this is an excellent idea, it still does not deal with the established fear most students have of the material. Without understanding how the students deal with the established anxieties over the subject material and knowing how it may or may not affect their learning process, educators have difficulty determining how to help students.

The purpose of this study, then, is to see how science anxiety affects adult learning. Once again, in this time of expanding technologies on all fronts, both academically and globally, the world is in desperate need of scientists in all fields. However, we are simply not getting the number of new scientists we need, and it appears that one of the root causes is science anxiety. In the past one hundred years, science and technology have become an integral part of our everyday lives. Without having the individuals to maintain and continue this advancement, our world may be in trouble.

Reason for Study

The reason for this study on the small scale, is to see how science anxiety affects adult learning. Specifically, I address how adults can learn in scientific courses with a distinct science anxiety affecting them. I also want to understand how some students can continue taking science programs with science anxiety affecting them and what drives other students to leave science programs. With this information I hope to find ways to directly deal with this type of anxiety and perhaps make the sciences attractive once again for students. In this way we can begin to stem the global loss of researchers so necessary for our modern world.

Research Questions

In order to better understand how science anxiety affects adult education, the following core question is the focus of this investigation: How does science anxiety affect students' experiences in adult learning?

This core question is reflected and expanded by the following sub-questions.

- How does science anxiety affect students' decisions to remain in or leave/drop out of science courses?
- What emotional factors influence a student's feelings toward science?
- According to students, what strategies can be used to foster learning despite science anxiety?

Significance

By researching science anxiety in adult learning, we could potentially understand the anxiety issues students' face and treat the anxieties more effectively. In the long term this may reduce the losses of students in scientific fields. Part of being able to learn is in the students' ability to feel comfortable with the material and not fear it or the learning process. This research will shed some light on how learning by students is affected by science anxiety and what educators can do about it.

By understanding how science anxiety affects adult learning, perhaps it will be possible to design solutions to overcome this impediment to education. Once this educational barrier is removed, it may very well open the doors again to science and math students to enter the fields without the feelings of apprehension about the material. In addition, by investigating how science anxiety affects a student's decision to persist or leave a science class, we could address the issues of student retention.

This information will be critical for any science, math, and engineering educator, regardless of discipline. It will, at least, provide valuable insights into the emotions of students and the potential reasons behind the fear of these subjects so critical for the growth and development of our world.

Definitions

Adult Age: For the purposes of this study, an adult is someone 18 years or older who can register for a college course and be considered a college student (see definition below).

College Student: For the purposes of this study, a college student will be defined as anyone eligible to register for a college level course for credit within a midwestern college system.

Traditional College Age Student: Ages 18-24, and for the purposes of this study are also considered adults.

Community College: A college with a 2-year educational program typically ending with an associate degree and prepping students for a bachelor's degree in science.

Fear: The unpleasant emotional state consisting of psychological and psycho-physiological responses to a real external threat or danger, including agitation, alertness, tension, and mobilization of the alarm reaction ("Medical Dictionary," 2013).

Anxiety: An emotion characterized by feelings of tension, worried thoughts and physical changes like increased blood pressure ("APA Anxiety Definition," 2013).

Science: For this research "Science" will be limited to the broad fields of chemistry, biology, geology, and physics.

Mathematics: For this research "Mathematics" will be limited to the broad fields of statistics, algebra, trigonometry, and calculus.

Science Course: A college level class of one semester, or 15 weeks, of study covering material pertaining to one of the broad categories of chemistry, biology, and physics.

Summary

The number of scientists and researchers needed in the world is decreasing and this potentially affects areas such as medical research, computer technology development, and chemical research. One of the root causes of this drain of students is science anxiety. However, science anxiety is poorly understood, especially at the college level. This research is dedicated to understanding how science anxiety affects college students in science courses. This research will shed some light into how learning by students is affected by science anxiety. With this understanding we may be able to find ways to alleviate this specialized anxiety to promote science learning and potentially increase student retention.

Chapter 2: Literature Review

While the literature is vast in the failings of modern (post 1980) science education, research into the emotional aspects of science education has not been performed on college students to a large degree, and few papers on the subject exist. To that end, this literature review focuses on the emotional aspects, specifically anxiety, fear, apprehension and stress in relation to a student's ability to participate in a science course. In addition, the idea of meaning making in science education will be discussed, but in the light of emotional aspects of learning. This serves to limit the vast amount of information on meaning making in education to a narrower field, making the literature easier to digest.

This literature review will be divided into the following sections: (I) A discussion of anxiety and how it manifests in people, and a discussion of science anxiety in particular. (II) Emotional aspects of science education, wherein the emotions of the student in learning the material are the focus, and how those emotions affect science education and comprehension. (III) typical science education today, focusing on the current techniques used in college science education, as well as the shortfalls and current state of undergraduate education in science. Finally, (IV) a discussion on gender and its effects on science education and the anxieties experienced by students.

The literature for this review was obtained from a wide variety of online search databases, including, but not limited to: ERIC, Google Scholar, Educational Full Text, EBSCO host, and PsychINFO. The library resources at the University of Wisconsin, Washington County were also used to obtain several Ph.D. dissertations for additional information. Search terms used were *science education, apprehension, fear, challenges, science education initiatives, emotions in science, meaning making in science* and *undergraduate science education*. It was found during the literature search phase that little research has been done on the factors of emotions in science education, so little to no restrictions in terms of age of the information were placed on those search results. In contrast, meaning making in science was restricted to articles from 1990 on in order to limit the overwhelming amount of information.

Articles were chosen by keywords found in their content, specifically those of science education, motivation, emotions, and anxiety in students. In total, 32 research-based articles and two books were selected that focused on the selected keywords, an additional 38 articles consisting of historical literature, practitioner pieces, and news reports were selected using the same criteria for selection as the research-based articles. Additional resources were found by utilizing the reference lists of other articles. Critical articles for this literature review are detailed on the table found in Appendix IV.

Theoretical Framework

The theoretical framework is a grounding tool used to guide how the researcher thinks about the research (Merriam, Caffarella, & Baumgartner 2007). The theoretical framework of this study is grounded in constructivist learning theory and transformative learning theory, where new concepts are constructed and added into a knowledge framework of an individual (Merriam, Caffarella, & Baumgartner 2007). However, in order for these concepts to be meaningful in any way, they must be incorporated and linked to past knowledge. This gives motivation to the student to actually incorporate the new information into their mental framework. These are founding principles of transformative learning, and constructivism is the foundation of concept mapping (Mezirow, 2000; Novak & Gowin, 1984) (see motivational papers as listed in Appendix IV).

Motivation is already discussed in terms of affective domains, but it is also a core reason for making some type of meaning of new information (Ausubel 1963; Novak, 1998). Educators already know that placing the information in context to the student's life is critical (Meizrow, 2000; Merriam, Caffarella, & Baumgartner 2007; Novak, 1984). In order to make learning meaningful to a student, educators must understand the emotional motivators they have for learning. This strikes at the heart of affective education, as well as placing information in the context of the lives of students (Ausubel 1963; Novak, 1998, p. 51). Dirkx (2008) points out that "Perhaps the most common expression of strong emotions in adult learning occurs around areas of conflict, in which there may be profound disagreement of values or interest, (p. 2)" which is the major issue that students have with science topics. The lack of connection between their values and those in science only reinforces the lack of context for the student.

Constructivism stems from contextualized learning, which focuses on making sure information presented to a student makes sense in terms of a student's frame of reference. An adult mind seeks a context to place the new information with the old established knowledge learned throughout their lives when learning new material. At the core here is the issue of ascribing meaning and context to a subject to be learned (Ausubel 1967; Novak, 1998).

Cognitivist thinking focuses on the core ideas of memory existing as an organized system. Because of this organization of memory, past knowledge is critical for current learning in order for the new information to make any contextual sense to the learner. (Merriam, Caffarella, & Baumgartner 2007). From these core ideas, researchers like Ausubel (1963) were able to formulate the ideas of meaningful learning in order to distinguish it from rote learning.

Simply put, knowledge is not simply acquired, but it is assimilated into our "library" of total knowledge and the organization of this "library" determines how useful this information will be. If the stacks are organized, the information can be filed and accessed easily, but if they are cluttered, then trying to find any information becomes difficult.

At the core of both cognitivist and constructivist learning is the knowledge that learning is active (Merriam, Caffarella, & Baumgartner 2007). Education as a whole involves active participation in the forms of dialogue, collaboration, and cooperation. Even in individual constructivist theory, it is known that one does not learn in a vacuum. The views of other individuals are required to truly test one's own knowledge structure as well as whether one can incorporate new ideas and interpret information (Merriam, Caffarella, & Baumgartner 2007).

The theoretical framework for this study also focuses on meaningful learning, which is a core component of both modern versions of cognitivist and constructivist theory, and stems from Novak's (1984) work creating concept maps in an effort to improve science education. Meaningful learning is a type of learning where the new information is related to an existing part of the learner's knowledge. In essence, one has to make the information relevant in some way to the learner instead of presenting the information and hoping it will sink in (Ausubel, 1963). This makes the challenge of education become less of what to teach, and more of how to make it relevant or meaningful. The critical aspect here is providing context for the information for the students. This ties back directly with Hinds' (1999) and Ediger's (1997) work showing that a context for science information is completely necessary for students to better understand the material. What the literature indicates is that by using both contextual and affective learning techniques it becomes possible for students to not only loose the apprehension toward science but to understand the material better. This should ideally be the goal of every science educator. However, meaning formed from material learned is ultimately dependent upon the individual

(Merriam, Caffarella, & Baumgartner 2007). It is the student who is ultimately responsible for integrating information into their current knowledge structure.

An individual constructs meaning from information by integrating new ideas into their pre-existing knowledge framework and then uses discourse with others to solidify or modify the information (Ausubel, 1963; Merriam, Caffarella, & Baumgartner 2007; Mezirow, 2000; Novak &Gowin, 1984; Novak, 1998).

Unfortunately, most of science education is not presented in a manner that makes it relatable to a student's prior knowledge in any way (Tobias, 1992; Tobias & Tomizuka, 1992). As an example, most biology professors when lecturing about DNA to RNA transcription would use the textbook definition of the process which is "DNA replication begins at a specific sequence of nucleotides called an origin. An enzyme called DNA helicase locally 'unzips' the DNA molecule by breaking hydrogen bonds between the complementary nucleotide bases, which exposes the bases in a replication fork. Other protein molecules stabilize the separated single strand so that they do not rejoin while replication proceeds" (Bauman, 2014, p. 199). In the above example, the book has introduced many layers of complexity such as replication forks, single stranded DNA molecules, and so on before a student is truly prepared for any of those complex concepts. A better way of explaining the information would be to try and integrate the knowledge with a student's frame of context such as saying "DNA is coiled like a twisted zipper, and when it is found that way it has to be opened up in order for any information to be accessed. The "zip" part of the zipper would be the enzyme called helicase, while the teeth of the zipper are chemical bonds holding the DNA strand together. As helicase moves down the teeth of the zipper, it breaks those bonds opening up the DNA and exposing it, so information can be read off of the strand."

Anxieties

Anxieties, in some form or another, have been believed to exist ever since the first human. In many ways, this type of physiological reaction to stimuli was an evolutionary advantage for our ancestors. Anxiety and fear responses kept early humans alive and were critical in our development by allowing us to recognize dangers and sense possible threats. Those traits still exist in our genes and are still being expressed in our behaviors. In fact, anxiety and fear are closely related in their mechanisms. The difference between anxiety and fear is that anxiety is a more diffuse and generalized emotional response, while fear is a response to a particular circumstance (Horwitz, 2013) (See Anxiety and Emotional Education papers in Appendix B).

Ever since we've had these emotions, humans have tried to diagnose and treat anxieties. From ancient Greek soldiers in battle, to confronting an incoming plague, to someone today worried about their sexual prowess (Horwitz, 2013), the basic mechanical effects of anxiety and fear are largely the same, resulting in similar pathways of the brain being triggered. With today's medical technologies we can even see the affected areas of the brain in action as people feel certain anxieties. Biochemically we know what reactions are happening in the neurons and what chemical signals are being sent. We now even have a host of drugs that can alter or end anxious episodes in patients (Horwitz, 2013).

That is not to say that we really understand anxiety. We know the basic chemistry and mechanics of anxiety in the brain, but the final effects on the individual vary wildly. Every person experiences different types of anxiety in very personal ways that are influenced by culture, social norms and personal experiences. This makes any definitive type of list of symptoms and disorders incredibly hard to develop. For example, soldiers in the Civil War were diagnosed with an "irritable heart" syndrome because of symptoms after a battle including: heart palpitations, cardiac pain, numbness of the arm, rapid pulse, shortness of breath, and sweating (Horwitz, 2013). Later in World War I, patients were diagnosed with "shell shock" with symptoms such as paralytic limbs, inability to speak, or even blindness (Horwitz, 2013). Vietnam vets diagnosed with "post-traumatic stress disorder" reported symptoms of flashbacks and hallucinations related to combat experiences (Horwitz, 2013). Each of these diagnoses of effects is different in their symptoms being expressed by the patients. Often this appears to be a culturally specific expression of the symptoms, and soldiers today have different symptoms as compared to those soldiers in the past. A common brain activity likely controls the responses of the soldiers, but the expression of the symptoms is culturally defined.

The main body of work that describes anxieties and fear and possible treatments is the *Diagnostic and Statistical Manual*. The *DSM* defines anxiety as a syndrome that occurs independently of any unique qualities of the patient or the period of human history it appears in (Horwitz, 2013). In essence, the *DSM* admits that the mechanisms are essentially the same to cause anxieties, but the symptoms are what are used to define disorders, and those can be difficult to determine. The *DSM* tries to categorize anxiety by the types of symptoms and their severity, but each edition of the work adds new disorders to an ever-growing list. The first *DSM,* published in 1980, had 15 pages devoted to anxieties, while the fifth edition from 2013 has 99 pages of anxiety disorders (Horwitz, 2013) with more being added or re-assessed all the time. The neurochemistry in each is incredibly similar, but the outcomes are different as each patient describes symptoms specific to them or their anxiety.

This has led to subsets of anxieties being categorized and ever more being created. Science anxiety is just one such example and follows close on the heels of math and statistics anxiety, test anxiety, and general school anxiety. In fact, many of these educational anxieties stem from the feeling of being out of control of a situation (Kurbanoglu, 2014). The things that set these anxieties apart however are the symptoms under which anxiety is felt. For example, someone with math anxiety would not have anxious feelings about an English exam. Science anxiety was defined by Mallow (1986) as the disgust or fear of science concepts, scientists, and scientific activities. This broad set of symptoms is often narrowed by defining the field of science and the specific circumstances of the feelings.

There are many ideas about how such anxieties have developed, but science anxiety appears to have a wide variety of causes. Broadly speaking, most academics separate knowledge into two categories; those of the sciences and those of humanities. The sciences focus on quantifiable data, while the arts remain qualitative. Mallow (1986) points out one of the core causes of science anxiety are the overemphasis of this difference between the two types of knowledge. This ultimately leads people to believe that there are distinct "scientific minds" and "artistic/humanities minds (p. 15)." This is extremely odd once one understands that science itself is a branch of philosophy, which is part of the humanities. However, once this distinction and separation took place, it has greatly affected the shape of how most individuals look at knowledge and types of education. This distinction is so strong that professors in the separate areas often re-enforce the ideas of how alien the other subjects are to their students (Mallow, 1986). Frequently instructors in the humanities point out that the sciences are uncreative while those in the sciences say the humanities are frivolous (Mallow, 1986). If the instructors reinforce this belief to the students, it may contribute to students entering the sciences with anxiety.

Another major issue in the development of science anxiety comes from the skills needed to learn and comprehend the material. Skills needed to learn science are fundamentally different from learning skills in the humanities (Mallow, 1986). As an example of this, consider that the physical sciences, chemistry, biology, and physics, actually rely very little on memorization and much more on logical deduction than most classes in the humanities. Students coming from one type of education to the other are often shocked at the transition and try to apply the tools of one to the other with little success (Mallow, 1986). Another example of the differences fueling science anxiety stems from how students approach the written materials of the subjects. As Mallow (1986) points out, when reading a play for the first time, a student will often skim the material and go back to it later to find a deeper meaning. Scientific papers on the other hand do not lend themselves to skimming of any sort, with even journal abstracts being heavily laden with terms that are unfamiliar to most individuals. This means that a simple quick reading of a scientific paper will yield the least possible understanding of its contents. A student anxious about science may wonder why it takes so long to read and understand something when the reality is reading scientific papers does take longer than reading a play and requires more focus than is typically asked of someone reading a novel or a script (Mallow, 1986).

This issue of the differences between the humanities and the sciences can also be exemplified by how much someone knows about the subject. In the humanities, a student can easily read a play or a poem and get the meaning. Sometimes this takes additional work on the part of the student to truly comprehend the piece, but that knowledge can and will come with persistence. In the sciences, however, there come instances where reading something and then trying to apply it suddenly becomes worlds apart. Written chemistry in a textbook is helpful, but it can never replace the physical act of performing chemistry. A student can learn a Shakespeare play from reading it repeatedly, but they will never fully grasp chemical processes unless they try to perform them (Mallow, 1986). It is this fundamental hands-on experience in science that many people struggle with causing anxiety.

Much of this distinction between humanities and science comes from the past history of science as a recognized field of study. Before the 19th and 20th centuries, science was not separated from the humanities, as can easily be seen in the early European Renaissance (Mallow, 1986). Before this point, science itself was widely regarded as "natural philosophy" and only an extension of philosophical thought. It was during the creative explosion during the European Renaissance that both science and the humanities flourished and became separate fields of study. In fact, Mallow (1986) points out that "the 19th century viewed science as a limitless source of treasure (p. 23). There was no widespread notion that science was beyond anyone's comprehension".

However, by 1930 science had become less and less accessible to nonscientists. Often this was caused by those in the scientific fields as they stopped doing public lectures and presentations and focused on making more and better discoveries. These scientists as Mallow (1986) puts it: "Jealously guarded their status by making science mysterious to nonscientists (p. 24)." This could be seen as the birth of scientific elitism and the rise of the idea of the "scientific mind" and "humanities mind." This point in history was so effective that this myth persists to this day. Thanks to this elitism, we can see how much of science is perceived as too hard to understand by anyone "lacking the mind capable of doing science." In many ways, scientists shut the door to outsiders themselves and the situation has only become worse over the years.

Of final note, is how scientists themselves are perceived by individuals. Mallow (1986) notes that while students see scientists as intelligent and mature, they also state that scientists are distant, disconnected from humanity, lacking in friendliness, and socially withdrawn. In this view a scientist is someone who gives up the ideas of family, culture, and social life for research and work. What is more disturbing is that science students themselves noted that scientists are highly intelligent but personally dull human beings (Mallow, 1986). Even educators in this field fall victim to this stereotype and reinforce it by criticizing other fields of study and work (Mallow, 1986). Moreover, emotions may be another key in understanding how people can have science anxiety.

Emotions in Education

According to Bloom (1981), there are three major domains of education. These are the cognitive, affective and psychomotor domains. The affective domain is largely ignored in most science education courses as it deals with emotional engagement with the material at many levels (Clark & Dirkx, 2008; Daston, 1998; Dirkx, 1997) (See Emotional Education papers in Appendix B).

The affective domain is a critical aspect of the learning process; however, and it has been shown that by engaging emotions in science that learning as a whole is greatly improved (Ediger, 1997; Hinds, 1999). The five aspects of affective learning as defined by Ediger (1997) are self-awareness (receiving phenomena), handling emotions (responding to phenomena), motivation (valuing), empathy (organizing), and social skills (internalizing values) (Krathwohl, Bloom, Masia, 1973). Comparatively, Hinds (1999) pinpoints six areas that correlate with the five sub-domains of affective education: context in terms of receiving phenomena (getting the information in a proper narrative to better understand it), self-discipline in the way one responds to phenomena (responding in a "mature" fashion), self-confidence in the way one responds to phenomena (not doubting oneself with a response to new information), motivation or valuing of the information (a reason to care about the new information), personal attention or a reason to organize the information, and extra help in terms discussion as a way of internalizing values being taught. When a student engages in each of these aspects in conjunction with cognitive objectives, their achievement is greatly enhanced (Hinds, 1999). In many ways the affective domain cannot and should not be separated from the cognitive domain in science education.

Many instructors feel that altering context or addressing emotional states distracts from the learning process: "Prevailing views often regard their (emotions) manifestation as a potential disruption of the learning experience" (Dirkx, 2006, p. 16). To deny these aspects of ourselves is to shut off an entire part of our minds, while trying to either teach or learn (Dirkx, 2006). As referenced by previous research (Ediger, 1997; Hinds, 1999) it is the overall perceptions of science as being difficult that engenders anxiety, decreasing any type of motivation to work on the topic. Only by recognizing that this emotional state exists can we, as educators, attempt to help students come to grips with the material in more than just a cognitive manner.

The affective domain of learning uses five sub-domains to give educators ideas of what to target when trying to reach students. Ediger (1997) and Hinds (1999) both use variants of the affective sub-domains in order to give basic examples of how to reach students in the sciences. Likewise, the concept of contextualization has been used to improve education by way of meaningful learning (Ausubel1963; Novak, 1998) both in and out of the sciences. What we, as adult science educators, need to do then is utilize both sets of techniques to not only improve science education, but to address the science anxiety held by students.

We cannot force students to learn material they have negative emotions about, but we can try to address the emotional issues and overcome them. This is what Dirkx (2006) describes as teaching with soul. This goes beyond just asking what a student is feeling, but instead really trying to understand how the emotions of the student affect their processing of the subject material. To do this we need to use the sub-domains of affective education by designing curricula that address the receiving of information, responding to information, valuing information, organizing information, and internalizing the information. These aspects can be built into curricula for science courses by looking at the emotional needs of students. By taking the models of Ediger (1997) and Hinds (1999), we can create curricula that, while focusing on science, also bring in the concepts of self-discipline, self-reflection, empathy, motivation, and social skills.

By applying the ideas of Dirkx (2008) to science education, we can get a better fundamental understanding of the emotional aspects of the fear of science in adult students. With this fear present and without a motivational reason (Meizrow, 2000; Novak, 1984) for education, there will be little use of the material outside of the class for the student.

As educators we need to be able to recognize the signs of a student coming to grips with who they are and how they relate to others, a process Jung (1969) refers to as individuation. This process is mediated through emotion laden images, tools we can use in lectures by making the information more meaningful than the standard information used in science education. These images should tie directly into the lives of students, showing them that science is not disconnected from their lives, but an integral part of it. Simply put, by using emotion laden images, thereby putting the information in context of modern life in the instruction, an educator will touch important feelings in a student's mental process, making a deeper connection to the information being presented (Dirkx, 2008). This is not advocating using frightening or obscene emotional images, but instead using imagery that ties the information directly into everyday adult life.

This serves a dual purpose of both making the information meaningful in a way that is contextual to the student's lives, but also makes an emotional connection allowing the process of individuation (Jung, 1969). This process is best done in a learning format where students can discuss the images and information both in groups and with an educator, allowing for the affective learning sub-domains to be worked upon as well. This type of learning helps with students' self-esteem (receiving and responding to information) in a caring environment (motivation and empathy) where emotions about the material can be discussed freely (internalizing the information) (Hodges, 1997; Krathwohl, Bloom, Masia, 1973). This can deepen their understanding of the material covered, not only in terms of achievement, but also in terms shifting an attitude from negative feelings to positive.

Science Education Today

Science, by and large, is taught using behavioral tools and theories of pedagogical education (Kuhn, 1996; Tobias, 1990). Most of these pedagogical techniques focus on the lecture and retain aspects of a topic being covered. While using these methods is traditional, they may not be the only way students should be attempting to learn. In addition to the emotional issue with regard to science anxiety, students have a profound disconnect from the material covered in science courses (Tobias, 1990; Tobias, 1992). Students need to have the content made meaningful to their lives in some manner (Ausbel, 1963; Novak & Gowin, 1984). The problem is that students are mainly assessed through academic achievement. There is little attempt to address the issues of the apprehensions toward the subject material, or to contextualize the content to make it meaningful to the students (Tobias, 1990; Tobias 1992). There is also little research regarding the emotional aspects of adult science education. Without understanding the emotional and contextualized needs of the adult learners in science, a student may never overcome the anxiety toward the material that blocks true meaning-making in learning; the social stigma of science will persist, remaining a barrier to deeper education in these subjects (Tobias, 1990) (See Current Science Education Papers in Appendix IV).

It is important to note that when one learns about science in most educational settings one is taught the mechanics of the scientific method, the basic reasoning processes, and the usefulness of "thinking like a scientist" without any attempt to place the information in context of a modern lifestyle or to appeal to the emotions of the students (Kuhn, 1996; Tobias, 1990). Again, with no context and no connections to their emotions, the motivations to learn science by an adult student are almost nothing. The study of science education has traditionally focused on achievement over engagement (Hertig 1976; Rowlands, 2001; Shermer, 1998) and with this in mind, it is no small wonder that many undergraduate students feel that science has little to offer them in terms of education (Tobias, 1990).

While some reforms to science education have been introduced as far back as the 1960s ("NIH Science Education Nation," n.d.), the major focus has always been on the mechanics behind the information rather than placing science information in context with a student's life. There have been calls for making more contextualized learning for students in the sciences with emphasis on problem-based learning, but these attempts have focused on K through12 grades and only seek to improve achievement of the students overall (Hertig, 1976; Hurd, 1985; Novak 1984). There have also been pushes to make science education more inquiry-based, making the education more hands-on in an effort to engage students (Hurd, 1985). The problem again arises when, at the core, inquiry-based education attempts to teach students how to think like a scientist (Hertig. 1976; Hurd, 1985; Kuhn 1996), frequently removing any kind of context of the information from the student's lives. The goal seems to focus more on changing how a student thinks instead of trying to get the information to fit a student's conceptions.

A student's attitude toward science also plays a role in his or her anxiety level for performing certain tasks. In a study focusing on statistics anxiety and attitudes toward science performed with 104 undergraduate students, it was found that those who had a low opinion of science had high statistics anxiety (Bui & Alfaro, 2011). Younger students (less than 25 years of age for this study) were found to have a negative view of science regarding social implications and their overall enjoyment of the subject. This attitude toward science was correlated with statistics anxiety, suggesting an inverse relationship, as previously mentioned. What Bui and Alfaro (2011) suggest from this research is that the development of a positive attitude toward science early on in education may be critical in overcoming statistics anxiety later on in a student's academic career. However, the authors also admit several limitations in their work such as students who did not perceive themselves as being creative, intellectual, or competent also showed high levels of statistics anxiety (Bui & Alfaro, 2011). This indicates that students' self-image and confidence also play direct roles in terms of anxiety. All of these factors lead to higher anxiety levels and result in poor performance, in addition to negative attitudes toward science, resulting in fewer students being interested in entering scientific fields.

This disengagement from science is something to be greatly concerned about. It seems that the only way for many professors to connect to all students in a science course is to have more classroom discussion periods in order to keep students engaged. Unfortunately, this is often not an option due to various budget cuts and restrictions caused by acts like "No Child Left Behind" (Epstein & Miller, 2011; Milner et al., 2012).

This is a serious problem on many levels, as students dealing with high anxiety levels toward a subject already have a motivational block toward the information, but also will often view the subject as a threat (Usera, 1984). This feeling of being threatened is just one more reason why so many students leave the sciences as a whole (Tobias, 1992; Usera, 1984). One problem with science anxiety is that no treatment methods have been identified. Anxiety is typically defined as a diffuse apprehension, something vague and broadly encompassing many feelings, while a fear is a reaction toward a specific danger (Usera, 1984). Fears can be targeted and treated while anxieties are much more nebulous and are often a whole collection of different fears blending into the feeling of threat toward the subject.

Science anxiety itself can potentially be broken down into six subunits consisting of: danger anxiety (anxiety in response to a perceived threat), science test anxiety (anxiety in response to taking a test), problem-solving anxiety (anxiety in response to making a decision about a problem), squeamish anxiety (anxiety in response to something the subject is repulsed by), performance anxiety (anxiety in response to performing a task at which the subject feels inadequate), and science classroom anxiety (anxiety in response to potential information overload) (Wynstra, 1991). These sub-anxieties were found and researched in 750 high school students using a survey instrument designed to detect science anxiety (Wynstra, 1991), but their formal definition is somewhat nebulous. Each sub-anxiety really only defines a smaller area of the overall feeling of discomfort in a student taking a science course, so in essence each sub-anxiety could also be seen as a cause of the overall anxiety instead of being separate feelings. In fact, science anxiety as a whole is sometimes discounted and blamed on poor background knowledge of the information by the student, many cultural and societal myths surrounding science, poor teaching of science, and anxiety felt by the teachers in regard to teaching science

(Epstein & Miller, 2011; Wynstra, 1991). While these factors may indeed be part of the reason for the feelings of science anxiety in a student, they are hardly the only causes for the problem.

Other potential causes of science anxiety include prior negative experiences in a science course, lack of andragogical approach to learning, poor study skills, lack of self-esteem, and the fear of failure (Tobias, 1990, 1992; Usera, 1984). The last fear is typically the focus for the limited amount of research done on science anxiety, which makes sense in that most students and academics focus only on the "passing of the course" (Tobias, 1990, 1992; Usera, 1984, p. 3). In terms of science anxiety studies issues of gender, social status, and age have been barely looked into. Science anxiety research also shows that there is no significant difference between traditional and older (i.e., 25 years of age and older) students in terms of science anxiety (Usera, 1984). Women, however, appear to feel higher levels of science anxiety than men as seen in two different survey-based investigations on the subject (Usera, 1984; Wynstra, 1991).

In fact, science anxiety has been categorized as just another type of test or math anxiety (Usera, 1984; Wynstra, 1991). However, this grouping of anxieties is unfair to the students suffering from science anxiety in particular. While there are similarities between the anxieties, the feelings of students having high anxiety in a science course cover more than just exams or problem solving, and in some cases the thought of even enrolling in a science class, can produce feelings of intense fear (Usera, 1984).

In a study performed by Sheila Tobias (1990), non-science majors were asked to enter science classes and record their feelings about the course during the semester. The results of these journals definitely show many signs of science anxiety in many of the students, as well as important recommendations by the students to possibly alleviate the problems. Perhaps the most critical of these recommendations is the removal of the feeling of sterility in a science classroom.

The distinct lack of a feeling of community or inclusion of the students was often reported by the participants in the study (Tobias, 1990, 1992). Many aspects of "normal" science education were seen as extremely off-putting, such as only lecture format teaching approaches, no real discussion sections, a distinct language barrier (i.e., scientific jargon), and feeling more competitiveness with other students than of cooperation (Tobias, 1990). If steps could be taken to address even some of these issues, the potential for student learning could be improved.

For example, the inclusion of even basic background context in science literature can make significant improvements to a student's ability to understand the information and ease potential anxiety. In an experimental study, 209 seventh and eighth grade students were presented written scientific content in two different contexts. One group was presented the information in terms of a scientific discovery narrative, while the other group was presented the information in a non-narrative format, as is typical of most scientific textbooks. The set of students exposed to the scientific discovery narrative performed significantly better on both immediate and delayed recovery measures as measured by the BEAR Assessment Framework (Arya & Maul, 2012).

The key element of this study, however, is the fact that the narratives on scientific discovery are focused on the emotional values and intentions of scientists in the texts. This addition of context and the emotional aspects of those involved in science had a profound effect on the students' ability to understand the information. Arya and Maul (2012) assert that this study shows that the "personal reader-to-text" connection to the narrative of discovery led to greater attentiveness to actual scientific content. Just writing about the "humanness of science" via the narrative of discovery on a subject can help a student understand scientific information better, showing that emotional aspects of education need to be better researched and utilized in science education.

When it comes to most science textbooks used in education, students find them overly serious and un-motivating (Otero et al., 2002). By adding the narrative of scientific discovery, Arya and Maul (2012) were able to show increasing student comprehension in scientific information. In another study, by adding the narrative of how scientists struggle to understand a subject and build their scientific knowledge, it was shown that students' interest in science actually increased, as well as improved their delayed recall of the material and their ability to work out complex problems related to the information presented (Hong & Lin-Siegler, 2012). In essence, this study once again focused on the human aspects of science research in order to relate to the students the emotional side of scientific discovery. By doing so, it once again made the material relatable on a more personal level to the students by providing context for the information.

Hong and Lin-Siegler (2012) argue that making the struggles of a scientist available to the students helps scientific learning by a) helping students to organize information to aid in recall due to emotional attachments, b) making scientific discovery and research more social and humanistic, c) increasing students' interest in science by placing information in a narrative context, and d) offering the firsthand thoughts and feelings of researchers to allow students a better understanding of scientific theory development (Hong & Lin-Siegler, 2012). The research conducted by Hong and Lin-Siegler supports their hypothesis, showing that students did indeed show increased comprehension of material presented when the background information and struggles of the scientists responsible for the work was presented in the text. Once again, by including a narrative about the emotional and humanizing aspects of scientific research, the material becomes more comprehensible to students and is retained much longer.

This problem is well recognized in educational arenas, where often special attention needs to be paid for science education, especially with adult learners, in order for them to complete science courses for degrees. Hinds' (1999) major suggestion focuses on doing needs assessments on individual students or small groups to determine the requirements in such areas as context, self-discipline, self-confidence, motivation, personal attention and extra help. It is Hinds's assertion that by dealing with these issues in such a manner we could substantially improve the quality of science education. Unknowingly, what Hinds suggested in this manner was the employment of affective and contextual techniques to improve science education.

Gender in Science Education

One of the largest issues in current science education is the gender disparity of individuals entering the sciences. Women, by and large, are severely underrepresented in the sciences, and many young women avoid the topics of science and math mainly because they are seen as topics for boys (Stoet & Geary, 2018). This has been a long-standing issue ever since the foundation of science as a discipline of study. There is a distinct need for gender to be addressed in science education as the concept of gender is important throughout societies and cultures. (Hussenius, 2014). Unfortunately, in many science fields the culture is male-dominated. Sciences as a male-dominated field originated with institutional environments such as early 20th century universities and the cold war military (Hussenius, 2014).

Based on male-dominated biases in the sciences, one might potentially assume that female students have a greater anxiety levels in terms of studying the sciences. In fact, previous research demonstrates, that female students tend to disengage from science courses more often than male students (“Disengage” 2010). Many assumed that female students did not understand how exciting science was and if they did, women would freely choose those subject areas (Hussenius, 2014). This however is not the case as all students, regardless of gender, seem to be avoiding the sciences. Female students in particular avoid the sciences not just because of the perceived difficulty, but also because of the male-dominated nature of the subject area (Hussenius, 2014).

There is little to no evidence that female students are less interested or capable of performing science than male students (Newall et al., 2018; Sikora, 2015; Stoet & Geary, 2018). In fact, in social and biological sciences women are now well represented (Newall et al., 2018; Stoet & Geary, 2018). However, in many areas of scientific research such as physics and computer sciences women are still underrepresented. This divide between women and men has persisted for well over 40 years (Miller, Eagly, & Linn, 2015; Newall et al., 2018). Despite the inundation of STEM (science, technology, engineering, and mathematics) programs to foster science education, female students are lost from the “talent pipeline” at every stage (Newall et al., 2018). Improvements to accessibility of science courses has not increased retention of women in STEM fields either, suggesting that there are more cultural and social problems causing this gender gap.

Unfortunately, the gap between men and women entering the sciences and then finding positions after obtaining an education has yet to be closed. Pervasive stereotypes about science being a field of research for only men emerge early on in childhood and exist across cultures (Hussenius, 2014; Miller, Eagly, & Linn, 2015). In many ways these are learned biases passed on from adults to children. In a study performed by Newall et al. (2018), researchers found that merely presenting as a female student over an internet chat with adult scientists altered the scientist's perceptions about the capabilities of the person talking with them. What the researchers found was that if the gender of the student was perceived by the adult tutor as a female, the tutor rated the participant as being less capable of doing scientific research in physics than when the participant was perceived to be a male. In addition, when the participants acted in "gender stereotypical female" ways the tutors perceived them as being less likely to enjoy science (Newall et al., 2018). The researchers concluded that females have a distinct educational disadvantage simply because of their gender and how they behave.

Another influencing factor in science education is one of gender stereotypes in the information being presented to the students. Gender-biased visuals, language, teaching approaches, and teacher attitudes are all aspects of how science is presented to young students (Kerkhoven, Russo, Land-Zandstra, Saxena, & Rodenburg, 2016). In judging just the visuals presented to primary school students it was found that the overwhelming majority of images depicting scientists were of men, while images of teachers were primarily female (Kerkhoven et al., 2016). If these stereotypes are in place just in the visuals we use to teach science to primary school students, then once again we are re-enforcing the gender bias ideas before these students even reach college levels of study. This sets up the mental idea that science is for men and not women, making women pre-disposed to avoiding taking science courses.

Even female students who go into science fields tend to choose different areas of research than male students. Overall, males lean towards the physical sciences such as engineering and physics while female students prefer biology, health, or environment related fields (Sikora, 2015). It was shown that for roughly each female who wanted to enter into the physical sciences there were four women who planned to work in the life sciences (Sikora, 2015). These choices are despite the fact that both genders take an equal interest in science overall. It seems that certain areas of science have opened up to more female students, but many of the “hard sciences” have remained closed and are still dominated by male researchers. This domination of these fields of research may be discouraging to females wanting to enter areas like physics potentially driving them away.

The perceived threat of gender stereotyping is a real effect on many female students. Using the stereotypical belief that men are better at math than women, researchers assigned a task to a mixed group of students (Hussenius, 2014). The control group in the study was told that they were doing work on a memory test. The other group was told the same information but also informed that gender differences would account for their mathematical performances. There was no difference between gender performance in the control group but in the test group of women performed 40% lower than the women in the control group (Hussenius, 2014). The idea here is that that the women in the test group firmly believed that logical performance was a male trait and that they would not be able to do the task requested of them. Therefore, when the researchers told the test group that gender differences could impact performance, it implied that the men were better at the mathematical tasks than the women in the test group (Hussenius, 2014). With these stereotypes in mind, as well as, the fact that certain areas of science are male dominated it is no surprise that women do not seem to be inclined to enter specific research areas.

One area that is confusing to many researchers is that in countries that appear to have excellent gender equality there are still massive gender gaps in STEM fields (Stoet & Geary, 2018). This is called the educational-gender-equality paradox and can be seen in countries like Finland and other Scandinavian countries. Finland’s female population actually outperforms males in science literacy and yet, it has one of the world’s greatest gender gaps in college degrees within STEM fields (Stoet & Geary, 2018). While women and men have similar abilities in science literacy, researchers found that science and mathematics were academic strengths most associated with males and this difference between males and females was more distinct in gender-equal countries (Stoet & Geary, 2018). This is potentially driven by job security in most gender-equal countries and more options being available to students for higher paying and lower risk jobs in research. The underlying idea is that the stereotype of males being better at logic driven sciences still persists, driving females away from the physical sciences and into areas where they believe they will be more comfortable.

Summary

Science anxiety is caused by many different factors that can be traced to many origins in both historical and social settings. This type of anxiety is similar to many types, but the root causes are unique and deserve particular focus in understanding the feelings behind them. Science education does not typically focus on the emotional states of the students. This is a problem as it ignores potential disconnects of the students from the material as well as turning a blind eye toward anxiety the students have about the subject matter. It has only been in recent years that the concept of emotions in science education has been researched. By and large, science education today focuses on achievement and results over emotional involvement of the students. Without the emotional aspect, many students become unmotivated to pursue science at all beyond the classroom. There also exists a distinct bias against females in science that has existed for over 40 years. While there have been many attempts to close this gender gap, it still persists and influences if women decide to enter the sciences at all.

Chapter 3: Methodology

This study was conducted using qualitative techniques focusing on interviews with students attending college science courses. A qualitative study method was chosen mainly because the information sought related to emotional states and perceptions of students toward science. Emotions are hard to quantify in any normal measurement and anxiety, while well defined, is not well understood from a measurable perspective. These factors suggest that for this study qualitative research techniques were the best suited to address the research questions (Creswell, 2008). In addition, this study is focused on the emotions and meanings behind scientific anxiety in students. This type of information is best obtained in a qualitative study.

Study Design

This qualitative study was an interpretivist study, focusing on science anxiety in traditional college age students and how it affected their learning. The interpretivist paradigm focuses on social construction of what we identify as reality (Creswell, 2008). This means that phenomenon, knowledge, and understanding are socially created constructs and can be interpreted via interactions with other individuals. Science anxiety is one example of such a phenomenon as students share their feelings with one another, warn each other of the difficulty of certain subjects, and talk about what material they like and dislike. In this manner, science anxiety (or any learning anxiety) appears to be a shared social construct and, for it to be understood, communication with those who deal with it is critical. Any type of behavioral uniformity between students would then be the result of social construction by communicating about the anxiety and not of a singular identifiable root cause of the anxiety. Each participant then would need to be assessed individually because of how the participant would react to their own interpretation of events. Each participant would interpret similar situations in their own way, creating multiple interactions to one type of stimulus.

Another reason for the interpretivist design comes down to the nature of the phenomenon being studied. Anxiety, of any type, can only be observed and described by the individuals experiencing it, much like symptoms of a disease such as nausea or pain. There are few external or physical signs that can be reliably measured, necessitating direct communications with those who deal with science anxiety. While rough estimates of anxiety levels can be made, the extent of how anxieties affect a person is not reliably quantifiable in a broad scale across multiple individuals. Each participant is bound to experience anxiety in their own way, making an interpretivist design necessary in order to frame each response accordingly (Guba, & Lincoln, 1994). The critical aspect here is that there is no way to have a single variable and control, as would be needed in a positivist study. Instead, using the interpretivist research paradigm, I was able to look at each individual and their own interpretation of how science anxiety affected them. This, in turn, gave me a better picture of how varied the responses to science anxiety were and how different individuals dealt with the anxiety. Each interpretation of the anxiety was considered in its own light, which allowed me to examine what types of meaning were being created by students and the ability to explain differences in responses.

The interpretivist world view is in contrast to a positivist paradigm, which posits that there is but a single world view, and therefore only one way to have, be affected by and experience science anxiety. This type of thinking lends itself to quantitative analysis of empirical data. Anxieties, while somewhat measurable, are ephemeral in nature and by their very definition, not quantifiable in any standard measurement. Given the emotional aspects of science anxiety, and how emotions can vary between research subjects, the positivist approach did not seem to be the best way to accurately investigate science anxiety as a phenomenon. Therefore, it was my hope to be able to interact with, interview, and observe students dealing with this anxiety and treating each world view as individually valid instead of trying to force each person's ideas of science anxiety into a single, rigid model. It is through social interaction, discussion, and working with many individuals that the reality of science anxiety can be defined and possibly understood.

Research Questions

In order to better understand science anxiety within adult education the following core question was the focus of this investigation: How does science anxiety affect traditional college aged students' experiences in attempting to learn science?

This core question is reflected and expanded by the following sub-questions.

- How does science anxiety affect students' decisions to remain in or leave/drop out of science courses?
- What emotional factors influence a student's feelings toward science?
- According to students, what strategies can be used to foster learning despite science anxiety?

Sampling

Participants in the study were selected from two consenting Midwestern community college campuses. The primary focus was on community colleges and not technical colleges due to the types of education each school employs. A community college offers a broader selection of courses but requires students to be well-rounded in course selection by stipulating students take courses outside a desired area of learning. A technical college focuses on trade skills pertaining to a specific type of job. The specificity of study in a technical college would undermine this study as student selection from a science course would be from students who all wanted to be in said course for their job training. By focusing on community college students, there was a more diverse group of students from which to select and, therefore, a better representation of the population. This also takes into account that most science courses taught at the community college level are considered entry courses into the sciences and often have a wide mix of ages and genders.

The main factor for selecting a participant in the study was if they were taking a science course. Students were selected for participation in the study based on the following criteria:

1) Students were of college age as defined as anyone eligible to register for a college level course for credit within the community college system.
2) Students were registered for a science course, specifically geology, chemistry, biology, or physics. These courses are of prime interest for this study as they constitute the "physical" sciences that regularly lose students.
3) Students were willing to be interviewed twice for approximately one hour per interview by the researcher and have prolonged discussions about the research questions.
4) Students were willing to have their responses recorded for data analysis.

Demographics like age and gender were taken into account once data analysis had begun (see below). Starting with a pool of 75-100 individuals that meet the above criteria, those willing to participate were given the Survey of Attitudes toward Science (SATSci) measure test to see if they had measurable science anxiety. This survey was an adjustment of the Survey of Attitudes toward Statistics (SATS) created and copyrighted by Candace Schau (Schau, Stephens, Dauphinee, & Del Vecchio, 1995) used to gauge whether or not students had statistics anxiety. (see Appendix A for full tool)

The survey contained 36 seven-point Likert items that participants were asked to select the best response from according to their attitudes regarding science (See Appendix A for all questions). Each item assessed one of six components (affect, cognitive, value, difficulty, interest, and effort) of students' attitudes toward science including: students' feelings toward science, students' feelings about their intellectual skills in science, students' feelings about the usefulness and relevance of science in their lives, student's feelings about the difficulty of science as an academic subject, students' level of interest in science, and students' amount of work predicted by the student to learn science (Schau et al., 1995). Figure one gives an example item from the SATSci with the "strongly agree-strong disagree" seven-point scale. Additional questions helped obtain demographic information from participants at the end of the survey. The survey took no more than 10-15 minutes for a participant to complete (See Appendix I for full survey tool).

Example Value item from the SATSci
1 -------- 2 -------- 3 -------- 4 -------- 5 -------- 6 -------- 7 Strongly Disagree — Neither Disagree nor Agree — Strongly Agree
Science knowledge is not useful to the typical professional.
Figure 1. Example question based off of the SATS-36 by Schau et al., 1995

Once students took the SATSci, their responses were scored, with higher scores indicating a positive attitude toward science and a lack of science anxiety. Scores on the SATSci-36 were formed by reversing the responses to negatively worded items (in items 4, 5, 7, 8, 11, 13, 15, 16, 18, 21, 24, 25, 26, 28, 30, 33, 34, 35, and 36, a score of 1 becomes a 7 and so on), summing up the item responses in each component, and dividing by the number of questions in each component. The affect component contains 6 items (3, 4, 15, 18, 19, and 28), cognitive contains 6 items (5, 11, 26, 31, 32, and 35), value contains 9 items (7, 9, 10, 13, 16, 17, 21, 25, and 33), difficulty contains 7 items (6, 8, 22, 24, 30, 34, and 36 see Appendix A for all questions), interest contains 4 items (12, 20, 23, and 29), and effort contains 4 items (1, 2, 14, and 27).

The scores for each of the six components range from 1 to 7, with higher scores corresponding to more positive emotions regarding science. For the purposes of this study, students were selected from groups that had scores of 4 and below in at least 3 of the 6 components. Any scores above 5 however indicated favorable feelings toward science in the respective component, excluding a student from participation in the rest of the research.

From the pool of students that had SATSci scores of 4 and below in three components, 8 students agreed to participate in this research and were interviewed twice over the course of the semester; once to establish their background feelings, attitudes and personal histories regarding science and once at the end of the semester to chart their progress and how they either moved forward or left the course. Two interviews were deemed necessary in order to chart the progress of the students in terms of their feelings (anxiety) about the course, their ability to find meaning in the subject matter, and how their learning skills and science anxiety either changed over the semester or persisted in a similar form to where they began. Indeed, anxiety and meaning making may have changed radically over the course of a semester and it is deemed critical to discuss these changes with the students as they happened.

Data Collection

Interviews were performed by following a set interview protocol, expanding or probing for more information as needed. The questions served as a general guideline for the information gathering of the interviews. The researcher let the participants talk at their leisure and only interrupted when more information was needed from a preceding question. The discussions were free form as the researcher posed the questions and let the participants answer in their own ways. The first set of interview questions to establish a participant's background was as follows:

1) Tell me a little about yourself.
    a. Where do you come from?
    b. What is your background/how were you raised?
    c. Where do you live now?
2) Do you feel like you have anxiety problems?
    a. Do you think you have science anxiety? Explain why you feel so.
    b. Can you describe an event in particular that caused you to feel anxious?
    c. Was this event an isolated incident? If not, please explain more incidents.
    d. Do certain situations trigger anxious feelings? If so, what types of situations?
        i. What do you do in those situations?
3) What was your best learning experience? What was your worst learning experience?
    a. Tell me about your all-time favorite subject.
    b. Tell me about your least favorite subject.
4) What do you think about when someone mentions science or scientists?
    a. Why do you think you feel that way about it?
    b. Tell me what you think most people feel about science.
5) Tell me about the best science experience you ever had.
    a. What do you think made it that way?
    b. Would you take a similar class today?
6) What was the worst science experience you ever had?

a. What are the circumstances that make it the worst?

b. Would you ever try such a situation again?

c. If you could go back and change things, what would you change?

7) How do you get motivated for a class you like or don't like?

8) Tell me why you are taking science courses today.

a. How do you feel about taking this course?

b. How do you think the science course will help you?

c. Are you looking forward to or fearful about anything in this class?

9) How do you study for science classes?

a. How do you make meaning out of information you learn?

b. How do you study for this course?

10) Tell me about what you plan to do once you graduate.

a. Do you think you will ever work in the sciences?

11) What do you think are the biggest challenges in taking science courses?

a. Can you give examples?

b. Can you tell me when this had a positive/negative outcome?

c. Would you change anything and, if so, how?

At the end of the class or upon a student withdrawing from the course, another set of interviews were performed to ascertain how science anxiety affected learning both in positive and negative outcomes. This second set of interview questions was designed to ascertain how the students may have changed in their feelings, anxieties, and attitudes about science over the course of the semester. The second set of interview questions are as follows (for a student that either fails or withdraws from the course questions are in parentheses):

1) How do you think your anxiety affected you this semester?
    a. Can you describe specific incidents or situations?
    b. Were there any specific times or places you felt more anxious than others?
2) Tell me about this science course.
    a. What did you find interesting and why?
    b. What did you find boring and why?
    c. What was the most difficult part of this course? (Did this part make you leave/fail?)
3) Tell me about the most meaningful thing you remember from the course.
    a. Why do you think this memory is meaningful? (Do you think this will help you in the future?)
    b. What made it meaningful to you?
4) How would you describe this course to other students?
5) Have your plans for graduation changed any over the course of the semester?
    a. If so, could you describe why they changed? (Have you been set back in any way by the outcome of this course?)
    b. If not, could you describe how they stayed the same?
    c. How do you think this class may have influenced your decision? (Will you take another science class, if so, what will you do different?)
6) Tell me about your biggest challenges in taking this science course.
    a. Can you give examples?
    b. Would you change anything, and if so how?
7) How do you study for science classes?

a. How do you make meaning out of information you learn?

b. How do you study for this course?

8) How did you think this semester went for you?

a. What were your best experiences?

b. What were your worst experiences?

9) What do you think about now when someone mentions science or scientists?

a. Why do you think you feel that way about it now?

b. How do you feel about this science course in particular after taking it?

Conceptual Framework

The conceptual framework for this study is a combination of cognitivism, constructionist theory, and interpretivism. Cognitivism and constructivist theory formed the basis of this research and interpretivism was the main philosophical approach used for data analysis in conjunction with the concepts of Wynstra's (1991) sub-domains of science anxiety which are:

- danger anxiety (anxiety in response to a perceived threat)
- science test anxiety (anxiety in response to taking a test)
- problem-solving anxiety (anxiety in response to making a decision about a problem)
- squeamish anxiety (anxiety in response to something the subject is repulsed by)
- performance anxiety (anxiety in response to performing a task at which the subject feels inadequate)
- science classroom anxiety (anxiety in response to potential information overload).

By using the sub-anxieties and interpretivism the data were analyzed to understand how the concepts that composed anxiety impacted the students over the semester.

Data Analysis

Before this study was performed, a pilot test using the interview questions was run using two doctoral students to refine the questions and interview style. Once the protocol for each interview was finalized, the interviews with student participants began.

Each interview was digitally recorded using an Olympus digital voice recorder (model ws-110) and then uploaded to a computer for transcription. The transcriptions were performed by an outside transcriptionist after sending the digital files via electronic mail. The transcripts, once completed and returned as word documents, were then usable for data analysis in the ATLAS TI software.

Once the transcriptions were obtained, the interviews were listened to again while reading the transcripts to ensure they were done correctly. The transcripts were then subjected to data analysis using ATLAS TI data analysis program. This software allows for the importation of the transcripts and the screening of them digitally for data pertaining to the research questions.

Two sets of codes were created for analyzing the data obtained. One set consisted of demographic information including gender, age, years in school, major area of study, and future plans for science courses. These codes were gathered over the course of the interview and pulled out of the transcripts for later analysis. The second set of codes are the major research codes used in ATLAS TI to analyze the data and emerged from the transcripts in specific phrases and comments. Initial codes were based on the identified sub-anxieties found by Wynstra (1991). These included:

- danger anxiety (anxiety in response to a perceived threat)
- science test anxiety (anxiety in response to taking a test)

- problem-solving anxiety (anxiety in response to making a decision about a problem)
- squeamish anxiety (anxiety in response to something the subject is repulsed by)
- performance anxiety (anxiety in response to performing a task at which the subject feels inadequate)
- science classroom anxiety (anxiety in response to potential information overload).

Codes were refined based on the data. Additional codes were developed from information given in interviews one and two.

Interviews one and two were compared using the ATLAS TI software and data-mined for similar or different responses and coding phrases that emerged between the two separate

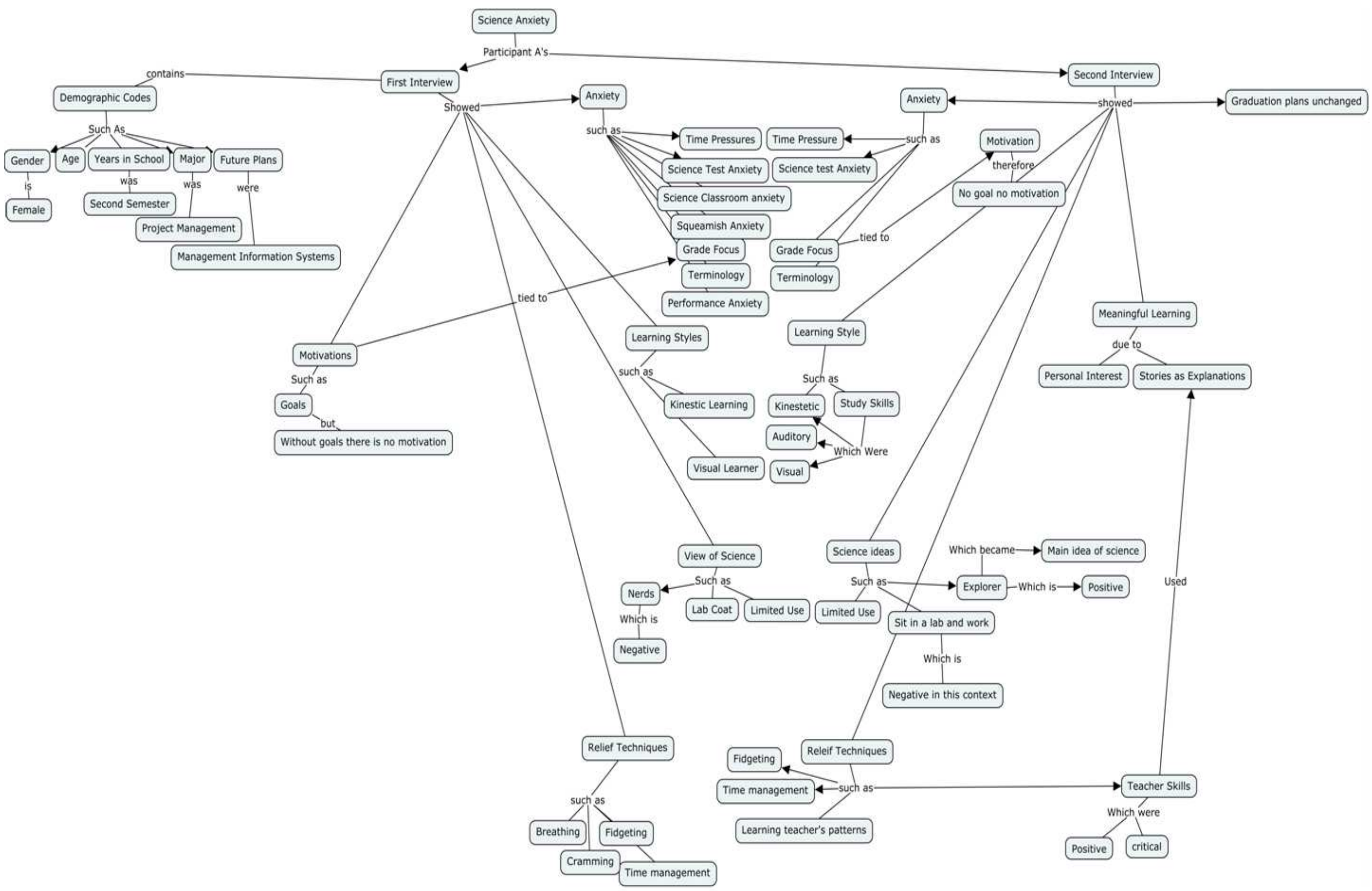

Figure 2: Example Concept Map from Participant A

interviews. Comparing interviews performed at the beginning of the research to those done at the end of the semester uncovered new codes for the changes in students' feelings and anxieties. More importantly the codes were gathered and compared to find similarities. When certain

similarities existed, such as multiple participants all acknowledging performance anxiety in some manner, that indicated an increase in the relevance of that particular code as a possible emotional issue relating to the overall effects of science anxiety.

Once coding terms were identified, the data were analyzed by first making a concept map of each participant's responses. The concept map combined both interviews into one visual diagram to aid in connecting the thought process of each participant and aid in comparison between the feelings at the beginning and the end of the semester. These maps were created using data both from the raw audio of the interviews and with the coded transcripts. These maps were then compared to maps from other participants to find similar responses or patterns of thought about science and science anxiety. This reinforced or refuted the initial scan of the data where similar codes were possibly found. An example concept map developed from the interviews of Participant A is shared in Figure 2.

In addition, the data were reviewed without the questions or responses by the interviewer to obtain only the participants story and points of view on the information being gathered. This eliminated any interviewer bias in the codes and allowed an unobstructed view of the responses without interviewer input. While personal experience of the interviewer may be important in some studies, here I was only interested in the responses of the students themselves. Finally, a short response matrix was also used to look at the data in comparison to the core research questions. The response matrix is as follows:

Table 1: Response Matrix used for Data Analysis

Student: ______________ **SATSci Score:** **Course Retention:** **(Exit interview only)**	**Interview Responses**			
Question (Interview Question)	**Student Response**	**Key Points**	**Anxiety Response (Wynstra's (1991) subcategories)**	**Relevance to Research Question**
How does science anxiety affect students' experiences in attempting to learn science?				
How does science anxiety affect				

students' decisions to remain in or leave/drop out of science courses?				
What emotional factors influence a student's feelings toward science?				
According to students, what strategies can be used to foster learning despite science anxiety?				

This response matrix allowed comparison to each interview question response to be analyzed against the core research questions of this study. This provided perspective on the participant's responses to questions in terms of their application to the overall research. This allowed me as the researcher to weed out responses and find those with most relevance.

With the responses by the participants, coded and mapped, emergent patterns were described. The emergent patterns were then related to the following research question: How does science anxiety influence students' experiences in learning science? Once initial analysis was performed these themes were then compared to the demographic data to see if specific themes resonate in specific age sets, gender sets and educational background sets.

Quality Control

The University of Wisconsin – Milwaukee Institutional Review Board (IRB) approved this study prior to data collection. Only responses by participants about their own experiences were subjected to data analysis. The responses of students were digitally recorded and unaltered in any way. Transcripts made from the recordings were performed by an outside resource with no connection to the research study or participants.

A one-hour time limit was set for all interviews. However, each participant was informed that this time limit was not formal and can be extended in order for every participant to tell his or her own story in their own way. Clarification of answers given in interviews were included in the data, as well as any other input students wanted to include after the defined interview was over (i.e., they remember something they wanted to mention after the initial interview). Detailed stories were the desired outcome of the interviews, and responses from participants with minimal input were probed for depth, or the interview redone if necessary.

To maintain confidentiality students were designated by a pseudonym such as participant A, participant B, and so on. In addition, all responses were accessible only by the primary student researcher (me) the major professor who may have needed to see the data, and the transcriptionist. Any commentary about the instructor by students was kept strictly confidential by replacing the instructor's name with the title <instructor>. Responses were kept for the length of the study and data analysis and then moved to long term data storage in a secure and encrypted hard drive owned by the primary student investigator. All other copies of participant responses were erased if digital or shredded if in paper format. All of these efforts are in place to ensure the quality of the information gained, the credibility of the recorded data, and authenticity of the responses.

At the end of the research process, an outside researcher unconnected with this project was asked to review the data collected in order to assess the dependability of the participants' responses. The independent researcher commended the concept maps and the response matrices as being clear and showing obvious signs of patterns emerging from the themes found in the interviews. This had the added benefit of addressing the confirmability of the study.

As a previous biology instructor, I have had direct experiences with science anxiety and the difficult nature of teaching science and helping students understand science. In my own observations of science instructors, most have either used the lecture and retain method of instruction or they have students read directly from textbooks. There were few instructors that made attempts to make the information more understandable by putting it into a current frame of reference. In my own teachings I struggled with finding better ways of making the language of science understandable, putting things in a current context, and making sure students were following my teachings by constantly asking them questions. This previous experience may lead to a potential bias in this research and contribute to the possibility of my position as a college professor, being a position of power over students, having affected the data gathering.

Therefore, in order to account for my own position as a college professor, students were assured in both verbal and written agreements that my presence and questions would not affect their grades in any form. Further, I emphasized my role as an educational researcher more than as a college professor. I did not speak of my own past experiences with the participants and focused instead on what they had to say. I also stressed that all information would be kept secure and confidential. No information would be shared with the campuses of the students' feelings about the courses or instructors. If my position or appearance of authority was disruptive to the research for a participant, they were replaced with another participant. Finally, all interviews were offered to be terminated at any time at the request of the student.

Summary

This study was conducted using qualitative techniques and grounded in a constructionist theoretical framework. Eight students were interviewed, and their responses recorded. These interviews were transcribed, and codes of information were extracted from the data for analysis. Information security, student privacy, and confidentiality were respected and performed to the utmost of the researcher's ability.

Chapter 4: Findings

In this study, eight students with confirmed science anxiety were interviewed about how that anxiety affected their ability to learn in a college setting. The themes that emerged from the interviews showed that the role of the instructor in the course was critical to the level of anxiety experienced by each student and that the overwhelming nature of scientific information alone was enough to cause anxiety in students. These themes were consistent across all eight participants showing that how science was presented, and the roles of the instructors were fundamental aspects of science anxiety as experienced by students.

The findings presented were obtained from analyzing at all sixteen interviews of eight participants over the course of one college semester. All eight study participants were female college students, either in their second semester or second year of college study at two different community college campuses in a Midwestern state. These participants all agreed to the interviews. Each interview was recorded and transcribed as described in chapter three. To keep the participant responses in focus and to interpret the data gathered, all interview questions were focused and aligned with the research questions for this study.

Research Questions

In order to better understand how science anxiety impacts adult education the following core question was the focus of this investigation: How does science anxiety affect students' experiences in attempting to learn science?

This core question was reflected and expanded by the following sub-questions.

- How does science anxiety affect students' decisions to remain in or leave/drop out of science courses?
- What emotional factors influence a student's feelings toward science?

- According to students, what strategies can be used to foster learning despite science anxiety?

In this data analysis, each of the participant's responses will be reviewed separately before a comparison is made between the responses to the interviews by each participant. Common themes in each data set will be identified for each participant before the final comparison of the data between participants.

The initial codes used in this study for data analysis were the subsets of science anxiety as described by Wynstra (1991). These codes were: danger anxiety (anxiety in response to a perceived threat), science test anxiety (anxiety in response to taking a test), problem-solving anxiety (anxiety in response to making a decision about a problem), squeamish anxiety (anxiety in response to something the subject is repulsed by), performance anxiety (anxiety in response to performing a task at which the subject feels inadequate), and science classroom anxiety (anxiety in response to potential information overload). Eight participants with identified science anxiety were interviewed in this study. Table 2 provides a summary of demographic information of the sample.

Table 2: Study Participants

PARTICIPANT	AGE	GENDER/RACE	YEAR IN COLLEGE	MAJOR AREA OF STUDY
A	22	Female/White	1	Business
B	24	Female/White	1	English
C	18	Female/White	1	Medicine/Pre-Med
D	19	Female/White	2	Biology
E	21	Female/White	2	Medicine/Pre-Med
F	23	Female/Black	2	Medicine/Pre-Med
G	19	Female/White	1	Medicine/Pre-Med
H	19	Female/White	2	Medicine/Pre-Med

Findings

Participant A.

Participant A is a female second semester college student looking to get into project management and information systems. She went to a chartered high school with a strong emphasis in mathematics and engineering. She had a strong math background entering college but readily confessed to feelings of anxiety, specifically performance anxiety. In her first interview, Participant A showed science test anxiety. She stated:

> So, when I get into class and I have a test that day or a quiz that day, I have to rethink like everything that I've been trying to memorize into my head, which makes me more nervous, and then I'm like, wait, was that that, or the other thing? And I start second guessing myself on the test.

She also showed signs of science classroom anxiety, mild squeamish anxiety, and performance anxiety. Performance anxiety was shown by her saying:

> But I'm used to getting a top grade and having it be fairly easy to get, and now I can't. I usually get A minuses, or a B, and that makes me pretty anxious, because I'm like, oh crap, I didn't do the best that I could, but yet it is, because I obviously can't get better.

In addition, she mentioned several points that add to her general anxiety such as the feeling of time pressures along with a focus on grades. In addition, the vast terminology used by biologists added to her feelings of anxiety. She stated:

> So, I took biology, which was a five credit. Mainly because I like nature and stuff, so it intrigued me, but when it gets down to like the nitty gritty, like, all the terms and stuff, I have a real hard time memorizing those terms, but I can tell you the processes that a cell takes to photosynthesis or whatever.

The grade factor is interesting to note here as Participant A states that she was used to getting all A's throughout her high school years and now in college she was receiving A minuses and Bs. Grades were definitely a motivating factor for her academic choices, as Participant A pointed out that without such a motivator, she would not be inclined to do the work. She expressed, “So its kind of those incentives make me actually go and the threat of my grade makes me try to do the class.”

The majority of her learning styles were tied to kinesthetic and visual learning, with some aspects of auditory learning included. When asked about meaningful learning, the major response from Participant A was to relate the information to areas of personal interest, or to tie them to stories or storytelling in a way of explaining the information. She explained,

> But for what I’m going into, I need to be able to find eco-friendly ways to fix the plant, or change new operating systems, and find efficient things. So, I think that will help me, and it’s just -- it’s something I enjoy, so it’s -- I can always look back on that and refer to that whenever I’m doing something. Like, if I’m reading an actual magazine or something, I love those things. I can think oh yeah, I read that in my course. I go home all the time and I’m like, hey mom, I learned a better way to water your plants and get them growing and stuff, because she loves plants. I -- yeah, I have like, little snippets of cool information that I’ve picked up, which is fun, because you would just insert that into conversation.

This is interesting in that it ties directly to the idea of teacher approaches in education and how an instructor presents the topics to the students.

When asked about her views of science in general, Participant A replied in the first interview that science is the domain of “nerds” and certainly has a limited scope of use in the world. Both of these comments were deemed as negative outlooks on science but not hostile. The second interview showed some change in Participant A’s views on science. While she still held to the idea that science is of limited use, her main idea of science became that of explorers and exploration, which is a positive outlook. She explained,

> I think just like the term explorer comes to mind. Someone who's fairly intrigued about something, that just wants to explore a topic more. Do FIAC (phonetic) and get like the observation hypothesis and all that stuff, and experiment, and just, yeah, someone that wants to explore and find a better way, or find the results of something, of putting a certain fertilizer in your garden, or figure out why your car won't lock, but you were just exploring to see if those concepts actually applied in real life, and how they applied in real life, and if you could take those and apply it to something else that you haven't experimented on. So yeah, you just -- like, it all kind of was exploring, I guess, that would be my new term for scientists. Is someone who wants to explore.

While dropping the position of science is for "nerds," Participant A did state that most of science is sitting in a lab and working, "I think it's awesome that some people can just sit in the lab all day long and test tubes and stuff."

As far as relief techniques used to cope, Participant A in the initial interview stated that breathing, cramming source material, and fidgeting were common physical activities she used to relieve anxiety. She explained, "Yeah. I try to breathe, and breathing doesn't work, so I usually fidget with my ring. That's why I have a ring, because otherwise I'll scratch my finger off." A more mental exercise for relief was time management and planning ahead accordingly. She stated, "So kind of like, having more time, more availability to do stuff, was very beneficial. And it almost lessens the -- like my nerves for it, because then it's not oh, crap, it's due tomorrow." Interestingly, while fidgeting and time management remained as relief techniques in her second interview, Participant A put a lot more emphasis on the approaches of the teacher and her own abilities to meet and learn the instructor's patterns. She stated that the role of the teacher affected the course a lot by explaining:

> She has all these personal stories and examples and stuff that she will insert. So, you get, like, you -- you get two things out of that. You get to learn about the professor, and you also get to like, have another example for yourself of whatever it is you just learned. And I think if she wasn't like, such a bubbly person, sitting there for an hour and 15-minute lecture, another hour discussion, and however long the lab is that day, it would just be so boring. It would go by so slow. Because sometimes we would continue a lecture into discussion, so you would get like two and a half hours of this -- of talking, which is boring, but her stories just like, they insert a moment of relief. I don't know how other teachers are, but for her, it definitely works with this class to keep you intrigued the entire time you're learning whatever it is.

This ties in neatly with her using stories as explanations for meaningful learning as the instructor for the science course in question often used stories and more personal narratives to explain complex concepts. She provided this example:

> I -- looking at her, like, I mean, in the answer, she's Muslim, so you'll look at her, and you're like, what is this person going to tell us about? Like how is she a scientist? And then -- but it's not like a lab coated scientist, she's like, she's a nature scientist, she just wants to explore, she's just like, she's awesome, and she's just like, it's -- it changes your perception, it's a new look on the teacher and on the field itself. I always thought scientists were lab coat-y, like, sit in the room all day.

The positive rapport with students as reported by Participant A was also critical for making the learning environment welcoming and aided her anxiety relief. As she states: "But then when you're in there, then she just, like the teacher just makes it so much more fun, so you're fine with it." These positive teacher approaches were critical in helping Participant A to learn the material and feel less anxious about the course overall.

Participant B.

Participant B is a female first year college student majoring in English. She was born in the South but came to the Midwest when she was three months old. Participant B went to a Catholic high school and was a ballet dancer for 13 years. While this was her first year on campus, she admitted to feelings of anxiety and stated that it was a trait that ran in her family, specifically with her sister. Participant B also stated that she did have feelings of science anxiety, specifically with feelings of being predisposed to failure in such courses. Of the subsets of science anxiety, Participant B showed in the primary interview signs of science anxiety by stating:

> Yes, I would say science anxiety, because I usually go into any science-based class and I think oh my God, I'm going to fail this. I'm not science minded. Up until 8th grade, I was pretty, you know, like, I was good at pretty much everything, and then freshman year of high school is when I started to see kind of a bit of a rise in English and history, and sort of a decline in science and math. I feel like when we think hands on science, we think dissections, and I hate dissections. I don't know if there's a way to make science more hands on that wouldn't freak me out.

These feelings, in combination with poor teachers previously experienced by Participant B caused most of her ideas about science and scientists to be negative. She stated:

> I didn't like the teacher, and I didn't like the way she taught the class, so I think it was probably a mixture of both, it wasn't a good structure for me, but I'm also not -- my brain doesn't work like that. It is biology, and it was -- we were doing metabolism. And I just -

> - I mean, that was the worst unit I ever did on. I mean it was awful. I just remember getting so frustrated with metabolism and cell respiration, and just not knowing what I was doing.

Specifically, Participant B felt that science in general was of limited use in the modern world and held feelings that only "smart" people can work in the sciences. She expressed, "Just, I mean, when I think about science, I'm like, oh my God, I hate it so much."

The poor teacher approaches such as poor interactions with the students and using teaching approaches such as primarily textual or auditory led Participant B to a feeling of extreme dislike of the instructor. She expressed,

> I hated the teacher. I would have liked to see how I would have done with a different teacher, and with a different class structure. She used a lot of overheads, and she lectured the whole time, so I would be interested to see if it was more -- if there were more like activities in it.

This, in turn, fed into her performance anxiety and science classroom anxiety, making her overall impression about the sciences as being negative.

These negative feelings were also carried into the second interview where Participant B expanded that science ideas are totally divorced from non-science subjects making the sciences seem exclusionary to all other topics. For example, she stated:

> I feel like you can't compare two different subjects together. Like, I could compare my creative writing and my American lit, because they're both under an English umbrella, but I feel like I can't really compare the heredity class to my English ones.

Adding to the poor teacher approaches were feelings that the instructor was inconsistent with the material as well, making it more difficult to understand. She explained,

> My high school teacher kind of played favorites, and she lectured super-fast, and she kind of glossed over certain things that she'd test really hard on the exams, but then she'd go really in depth with things that we didn't really need to know. So, it just, it felt very inconsistent, whereas this term, it was -- what we needed to know, we were taught.

Participant B did state that some positive feelings towards the sciences existed in her world view that showed in both interviews. Those positive feelings were linked with how she viewed society and how society, in her eyes, felt about science. In addition, Participant B made the astute point that a person's age played a role toward how someone feels about science, as children overall seem to have better experiences dealing with the subject. For example, she stated,

> No, when I was a child, actually, I had this electronic circuit set thing, and it was the coolest thing I've ever gotten, so, you know, work around with, and yeah, eight or nine years old and I was totally into the electricity and circuits and stuff like that, so that was probably the coolest science thing for me. I'm a really hands on person, so having those circuits, and being able to touch them and feel them and look at directions, and kind of get to play with how they worked and getting to change the directions every once in a while was really fun, so I think it was the fact that it was hands on which made it so fun for me.

Finally, Participant B stated that more interaction and physical involvement with the subject greatly aides her feelings of positivity. This statement linked nicely with her preferred learning styles from the first interview, which she described as being primarily kinesthetic and visual. It is interesting to note here that in the second interview Participant B stated that her main modes of learning over the course of the semester were focused on textual and audio styles, which were the modes used by the science teacher she reportedly hated. This may have been a shift caused mainly by not being required to read the text and doing so under her decision by allowing her to find out for herself that reading was helpful instead of forcing it upon her. She stated, “Yes. I did much better in the first half, when I was reading. And -- not much better, but I definitely did better when I was reading the textbook than when I wasn’t.”

Motivation for Participant B focused on grades and a feeling of having to do the work. These feelings were established in the first interview and were seen to persist into the second interview. However, Participant B did elaborate that grades were not seen as a measure of knowledge and didn’t help her in meaningful learning of the material. She explained by saying:

> I mean, science and mathematics courses, things that I’m not going to use every day at my job, was more of a, I’d like to get a good grade to have a good grade. Not really so much do I really understand the material? Do I know the material? Do I appreciate the material? It’s more of just something that you have to get done, and if you can get a good grade on it, that’s all the power to you.

She often uses the motivation of trying to understand to keep her focused and keep working on the material. One challenge Participant B reported was losing motivation in long classes, as time seemed to drag on for her.

Participant B reported in the first interview that meaningful learning, for her, came from personal interests and good teacher approaches, such as student encouragement and engagement by the instructor. As an example, she stated of her instructor: “She was just -- she’s a very logical person. She was really straightforward, she was super open with the students, and she was very giving of her time.” This was repeated in the second interview with good teacher approaches being a significant part of anxiety relief for Participant B. In addition, use of practical examples and application of the information and linking the information with stories to teach the subject also made the material meaningful for Participant B. She stated this as an example:

> She would do sometimes, when we were talking about a particular type of irritant, she would bring up an example of a common disease. So, like when we were going autosomal dominant stuff, she brought up Huntington's. So that was cool, so she did have some, you know, modern illnesses and disorders mixed in the lecture.

Anxiety relief for Participant B was directly linked with good teacher approaches, specifically when instructors were giving with their time and made efforts to directly contact the students. This aspect of relief also tied directly into meaningful learning for Participant B as the instructor used personal interests, stories, and practical applications of the information to make the material more approachable to the students. She explained:

> I'd often wondered if maybe the reason I hated biology so much was because of my high school teacher, and I think it was just the teaching approach that she had was not as good as the one that my professor had this term. And I think that it reinforced the idea that maybe it's not the -- maybe it's not me, it's the teacher.

Participant C.

Participant C was a female second year nursing student and in the initial interview stated she did not have any general anxieties, though there were some science anxieties she felt toward the subject matter of the course. Participant C came from a private school background from K-12 that was a Baptist academy where classes averaged about five people. She stated,

> So, I had, like, you know, from about five people in my class, usually. So, for like all my classes, they were usually combined like in high school, so it'd be like 9th and 10th, and then 11th and 12th.

The primary sub-anxieties of Participant C were science classroom anxiety and performance anxiety. She stated,

> Just the thought of science classes usually gets just like overwhelming sometimes because it's just, I don't know, there's so many -- it's so broad, science, you know? And I'm a perfectionist, too, and usually, like, I wouldn't get a good -- like the best score on labs, so that's probably why I don't like labs, either.

These anxieties did not change between interviews one and two. Participant B explained:

> I guess I get the anxiety more so at the beginning of the semester, because it's just like all new and unknown. And I don't like new things and unknown and change and stuff, you know, so then once I get used to like what the class is, and like what is expected and stuff, then I'm okay.

Participant C also stated that she loved learning in general but tied most of her feelings of anxieties directly to poor teaching approaches of the instructors. In particular, she mentioned that labs in general were the worst parts of science classes.

> Well, like how we did labs, we had like a worksheet that we would have to read beforehand, and then we had to like answer pre-lab questions. And then just the whole process, like the way it was written, I think, like the manual we had, it wasn't very clear. So, you know, that's kind of hard. And then it was like very detailed, like too detailed, you know, but yet it wasn't specific enough. You know it was kind of one of those. So now I just don't like labs. So, like when we have labs on Thursday, I'm like, oh no.

Participant C's primary motivations were focused on good grades and maintaining a high GPA. For her, grades were a positive motivator, leading her to focus on the tasks at hand and succeeding in science courses. She stated, "Grades definitely motivate me. Yeah. I like having a 4.0. So that motivates me to just work hard, and my parents motivate me, too, to work hard, so that helps."

Participant C's learning styles focused mainly on writing, reading and visual learning styles, which tied in with her tools for anxiety relief skills. For her, getting to know patterns of the professor and the subject material helped greatly to counteract the feelings of anxiety caused by the course. She explained,

> You know, because I don't know. Usually, like I, you know… fall into a routine and get used to it, but at first, it's like overwhelming to look at everything, you know… look at the syllabus and like, oh my, we're going to cover all this.

In addition, being able to plan ahead and use study skills learned over her academic career greatly helped to reduce the amount of anxiety felt in classroom situations. A specific example used by Participant C was that of color coding of materials, which links with her learning approaches of being a visual learner. She stated,

> I get out my planner. And I plan. I do. I study a little bit each night so that it's not as overwhelming. And I try to like, go over like notes after class, and like, rewrite them, and like, color-code them.

It was also critical for Participant C to be able to determine specific versus broad information in order to understand its importance in the material presented. She explained,

> Be a little bit like more specific to this thing I guess, more, so than like… so broad. Like with physiology, how it's broad, like… I was saying. Like… focus on one thing. And I know we are focusing on like one thing at a time.

Learning was made meaningful to Participant C when linked with personal interest in the subject material and demonstrable, practical application of the information. In addition, learning in the context of stories used as explanation or examples was of great help in making the information more meaningful. As an example, she stated,

> Well, I enjoyed anatomy and just learning about that last semester, and like… I think about it sometimes, like when, you know… something happens, and I'm like… oh, I know what muscle that is. And like I dislocated my knee, you know… so I thought about like that, and like… the muscles and all that stuff. So, I'm kind of excited to learn like… how it actually works, you know? Instead of just like… knowing where it is, like I'm excited to learn like how it works.

Participant C's ideas about science and scientists were largely positive when viewed in a personal light. However, when asked about social implications about science, her responses were largely neutral, and she readily admitted in the second interview that most science was limited in use. She stated as examples:

> Scientists, I usually think of like someone in a lab doing chemistry. Stuff like that, you know. Probably because that's like what I grew up, you know, with, like you watch TV and it's like scientists, and you know they're the white lab coats and the little test tubes, yeah. Where like chemistry, I feel like I'm not going to use it. I know I will when I'm a nurse, but I really just don't feel like it will.

Participant D.

Participant D was a female second year college student who planned on going into a nursing program after initial requirements were met. Participant D is a Midwestern native and her father is one religion, while her mother is of a different religion. The semester these interviews took place was particularly busy for Participant D, which led to what she called an "overwhelming semester" and really challenged her time management skills. This came from taking 18 credits in classes where 12 is considered a full load, being active in multiple sports and working several part time jobs that took place over the course of the semester. She stated, "Like, I have two, three jobs now, I play a sport. Technically two at once, because I have volleyball once a week. And I'm taking 18 credits this semester."

The major driving motivations behind Participant D were her desires to go into nursing, maintain her GPA, and an overall feeling that the courses to take to become a nurse were things that had to be done to obtain her future goals. While these drives are admirable, Participant D also admitted that motivators, like grades, did lead directly to her feelings of anxiety.

Participant D's anxieties were tied to the overwhelming nature of the semester, feelings of time pressure and inadequate time management, plus the need to maintain a high GPA. She explained,

> I'll admit I don't study as much as I should. It's a matter of self-discipline, I guess. There's just -- with me, personally, there's so much going on my plate that I'm so tired, and I get so -- I just -- I find myself --laying down -- right, and I know that I should study more, and that definitely with courses like physiology, I'm going to have to. So, I'm going to have to kick it in the butt a little more than I want to.

These gave rise to specific sub-anxieties such as performance anxiety, science test anxiety, and science classroom anxiety. As examples she stated the following:

> So, for me, it's mostly the pressure of, a lot of nursing students have 4.0s, and I'm not a 4.0 student. I'm an A/B student, but not to that level. But when it comes to like everyday classwork, or just taking notes in lecture, like nothing is triggered then. I think it's just when I'm assessed on it. Physiology, I'll be honest, I'm not super excited for, because I know it's going to be a lot more difficult than anatomy because it's at a more complex level. I mean, I feel like the assessments are going to be a lot nicer, because there's multiple choice and there's matching and all that stuff, so it's not like, oh hey, you have to remember everything for fill in the blank, which is nice, but I don't know. I've already noticed just like making up lectures at home and stuff on PowerPoint that it's going to be a lot different, only because for anatomy, I feel like it was a lot more memorization of like where things are and how things function versus memorizing like parts of the body, and we would get a list of things you had to memorize, versus with PowerPoints that I've had so far with physiology, it's a lot of more in depth slides, and I feel like it's more like weeding out what you think is important.

These anxieties did not change between the initial and secondary interview. Participant D's learning styles focused on kinesthetic learning while writing and reading were also emphasized. The hands-on aspect of the labs was of particular interest to Participant D as this also becomes an important point for her in terms of meaningful learning. For Participant D, meaningful learning was fostered by the hands-on elements of labs, but also was aided in particular by her personal interest in the subject matter. She explained,

> I feel like labs are interesting, just seeing how things react, like what we're doing today too, with putting different solutions together and I don't know, just seeing the reactions of stuff, because that's not something that you get to do every day. I found that really interesting, just learning how there's different types of reflexes, like you knew some were automatic, but I didn't know they could be broken down even farther, and then -- I don't know, just getting to test things, like not even just that lab, but other labs, where you could hook up to like the simulator on the computer, and like actually see how your body's working.

In addition, in the initial interview Participant D states that the approaches of the teacher have a huge effect on if meaningful learning is accomplished. When a teacher shows good approaches in instruction, such as sharing stories to explain material, it makes the information more personal and easily understood. When a teacher shows negative approaches, such as showing signs of not wanting to be in the classroom or has an approach that clashes with the preferred modes of learning of a student, it can negatively impact meaningful learning. As an example, she stated,

> I mean, I'm not one to quit, but honestly, I feel like I wouldn't have even taken it for a semester, knowing -- if I would have known how the teaching approach was, and how difficult the class would have been, I probably would have said, no, I'm just going to wait until college to take it. But everything's an experience, and you live, and you learn, so I mean, I don't completely regret it.

Participant D's ideas about science and scientists from the first interview showed neutral to negative feelings toward the subjects. In the first interview, she stated that a lot of science appeared to be age gated, where younger students held no fear of science while older students constantly felt a pressure not to act too intelligent or ignorant. She stated the following as an example:

> I feel like when you're a child, and you're in your younger years, there's not a lot of fear there. Like, you'll see kids that stand at the top of a fire pole, and they'll just jump off, or they'll go on the tallest slide, and just go face first, and you don't see fear very present in kids. And I feel like as you get older and the more you learn, and the more you've been in school, I've tended to notice that people get more afraid of thinking they're stupid.

Participant D also professed that science was not a subject for everyone and was limited in use. She felt that the topic itself could be used to weed students out of the subject entirely if they were not fit or intelligent enough to study the material. These viewpoints persisted into the second interview and remained unchanged as can be seen by her comments here:

> But I think a lot of people don't realize that when you're going to major in something medical and you take all these science courses, they're kind of meant to weed out the people that aren't meant to do it. That's how I look at it. I don't know, just the difficulty of the courses, I'm like, if it's just something that you're taking to fill an elective or fill a credit, take something else.

Anxiety relief for Participant D focused on either making an area relaxing or by working on particular study habits. She reported that specific places and sounds were comforting to her, such as being inside the gym offices and listening to the sounds of basketball practice. She explained,

> I would go down, because I hang out in <instructor's> office a lot. I would sit in there during the guys' practice, I don't know what it is, but since I'm almost always in a gym, just like the background of hearing like the balls dribbling, it kind of helped me.

Her other tools consisted of constant studying and quizzing herself on the material but doing her best to make it into a game like a trivia quiz. Lastly, Participant D stated that just forcing herself to focus on her motivations and power through the feelings of anxiety were effective for her to keep moving forward.

Participant E.

Participant E was a second-year female student with plans on entering a medical field of alternative medicine after graduation. She attended private schools before high school, and subsequently dropped out of high school at age 16. Participant E obtained her HSED (High School Equivalent Degree) at age 18 and then entered college. She was medically diagnosed with anxiety, which mainly manifested as social anxiety. The major sub-anxieties of science anxiety that Participant E showed were those of performance anxiety, squeamish anxiety, and science classroom anxiety. As examples she stated,

> I remember being like a kid, and like being having to go up to like the chalkboard or whatever, or -- yeah, it was a chalkboard, but you had to go like do an equation. I'm that old. And I remember always being like, oh, she won't be able to do it, she's just a dumb blonde and things like that. You know, dissecting a body's not comfortable. I was nervous going into like the geology one, because I don't like know any of that, but I needed a natural science.

Exacerbating Participant E's social anxiety was a series of poor instructors. These instructors did not actively teach the courses she took and had questionable social skills with students, which led to many uncomfortable situations. As an example, she stated the following: "I always kind of felt like he was flirting with students. Like, I totally felt like that." Ultimately this caused many students to drop the science courses in question. This only lent to the feelings of social and science anxiety felt by Participant E in previous science classes. She told me, “I’ve never -- I don’t think I’ve ever experienced a worse professor, or worse like, teacher in general. He was bad.” The feelings of social anxiety never changed between the first and second interview. As an example, she stated,

> Where I’ve been like -- like even yesterday, like, I wanted to leave class, but I didn’t. But yeah. Like to the point of almost having panic attacks, like, my watch tells me my heart rate, so my heart rate will go up, and I can’t like -- you know… I have to breathe, and just things like that. I mean, I tough through it.

However, performance and squeamish anxieties were not present in the second discussion. Participant E only felt overwhelmed by the information presented, which is part of science classroom anxiety. For example, she stated,

> Every class we have like, so many questions that we have to have done, and every class period, like, before we get -- when we -- at the beginning of class, we have a quiz we have to take, so I mean, there’s just stuff like that.

Participant E stated in the initial interview that one of her biggest challenges was time management in terms of science courses in general. She explained,

> I think the biggest challenge is like managing, like time managing it. Like, with anatomy, it’s all a lot, and there’s like labs and lectures. It’s a lot of different things being thrown at you. I think it’s just about managing them and like, keeping them separate, I guess.

This was tied to feelings of being overwhelmed by the information but was lessened by certain behavioral changes and practices she performed over the course of the semester. One of the biggest things that helped to counteract her anxieties was good teacher approaches, such as when a professor took the time to interact with the students and made active attempts to educate on the material presented. She explained:

> I think the environment, like the positive energy that the professor totally brought to it. I think that made -- like, everything feel comfortable in like an uncomfortable setting. You know, dissecting a body's not comfortable. And then having someone be there that's positive, laughing, making it fun, I think that's what made it a good experience."

Not only did these interactions help to reduce the anxiety felt by Participant E, but it also was a major factor in making the information meaningful for her. This type of meaningful learning was seen in both interviews.

In addition, meaningful learning was also seen in the second interview as being tied to personal interest in the subject material being taught. She explained, "So I think it's just like interesting finding out how like, hurricanes work, or flooding, or like, everything like that. Like weather patterns, and I think that's all really interesting." The repetition of thoughts and ideas so that they would stay focused in her mind also helped as she explained, "God, I don't know. That people die in cars in flooding more than Yeah, why I think of that, I don't know. That's probably the most thing I would say, because he says it all the time." Her main learning style, which was reading based also contributed. Her other learning styles, as shown in the first interview, were writing out the material, kinesthetic, and repetition of the information. This was supplemented by taking quizzes to refresh the information.

Participant E's motivation for these classes came from a feeling of having to perform the tasks in order to achieve her goals. She explained,

> I just think about it as a way that like, I paid for this course. I need it to go anywhere in life. Like, if I want to become anything, if I want a career, I have to just push through.

Interestingly, however, grades were seen as a negative motivator to Participant E and were not helpful in measuring her progress. She stated, "I don't personally think grades are a good motivator. I mean, they are, because like, everybody wants an A. So, I mean, it pushes them to keep trying, but everybody learns differently."

Participant E's thoughts about science and scientists from the initial interview showed that in a personal context they were mainly positive to neutral in feeling, mainly due to having family working in the sciences. She stated, "You know, I guess scientists, is like, it's really comfortable for me, because she -- well, I guess she's my ex-sister-in-law, but we still like to associate." In a broader social context, her feelings were mainly negative about science and scientists. She explained,

> I do think they think like, white lab coat, like scary things, like experiments, that's what I think of when I -- I don't know. Because you always see like scary movies like in labs creating like crazy things like Frankenstein stuff.

The second interview, however, showed that after the course she took, her feelings were mainly positive about science and scientists. Much of that she attributed to the instructor of the course, who had good teaching approaches that greatly improved the class for her. She explained by saying,

> I don't really think evil scientist anymore, I guess. I don't really know. Because I don't -- I think it's -- I don't know, I think the stereotype of the way people look at it is kind of wrong, you know? I think that's kind of what changed.

Anxiety relief for Participant E in the initial interview came from the use of certain oils, breathing techniques, and time set aside for relaxation. These tools were used for her medical anxiety, as well as her feelings about science anxiety. These tools were supplemented as seen in the second interview by changing her diet to that of veganism. Participant E felt that this behavioral change had a profound effect on her mood, outlook, and greatly alleviated her social anxieties. She stated, “So I just chose veganism. And I felt better after doing it, I had less anxiety, I was just like happier, I was like, everything just kind of changed.”

Participant F.

Participant F was a second-year female student with plans to enter a nursing program after obtaining her bachelor’s degree. She was homeschooled until the age of seven, was married at the beginning of the semester but separated during the year and had a four-year-old child. Participant F worked full time and was in school full time as well. Participant F was also medically diagnosed with anxiety and depression. Part of her anxiety came from an overwhelming schedule between school and personal life activities. She explained,

> I switch my schedule around. I have a nanny, and, so like, I work Tuesday nights, Wednesday nights, Thursday nights, doubles on Fridays, during the day on Saturdays, and then I switched my schedule, so I could have off Saturday night, Sundays, and Mondays, because they don’t need me on Mondays. It’s slow as all get out.

Specific sub-anxieties were science classroom anxiety and science test anxiety. As an example, she stated,

> Because it just -- it’s harder, it’s a lot of information to absorb. Whereas like, let’s say like math class, it’s like, okay. I practice this, I know it’s going to be on the test, I can learn it. Science it feels like anything could be on the test.

Participant F stated in the initial interview that science test anxiety was one of her biggest challenges in taking science courses.

So, like, when I have anxiety though, like for the first test that we took here, like I start shaking, and feel like I'm going to throw up, and like, I can't breathe. Like it feels like someone's squeezing my chest. Like that's how bad it is.

These sub-anxieties did not change between interviews one and two, however her biggest challenge in taking the science course did shift to time management in the second interview, when she stated,

And don't try to pile on 17 credits while taking that class. Because it's hard, and it requires a lot of work, and a lot of -- hell, I can't think of the word. A lot of down time where you need to study by yourself, so if you don't have the time, you need to either make the time, which I get is hard, or take the class when you can take less credits in the semester. And like, I can't, I just, I don't learn that quickly.

Participant F's main motivations came from a feeling of having to do the course in order to move on to the next stage of her future plans. She expressed,

I have to like -- I never get -- half the time, by the time I get to class, I'm not motivated to be there, but once I start doing the work, then it's like okay, you can do this. Just get into it. You have to go to school. You need to get up. You can't lay in bed all day.

In her case, however, grades were seen as a negative motivator, which ultimately damaged her self-confidence. She explained,

I know with my workload and how much pressure I put on myself, that I'm not going to get a 4.0. But I know that if I study hard enough, I can at least get a B. Like, that's my goal, is to get Bs this semester.

This lowered her self-confidence ultimately and increased her science test anxiety. She stated, "That I'm going to fail, because I have really low self-esteem. It's like, I worry about everything too much. I put way too much pressure on myself, and I take on way too much, all the time."

Meaningful learning for Participant F was tied to personal interest in both the first and second interviews. She explained, "I am going to school for nursing, so I guess it doesn't shock anybody that I'm interested in the different breaks of the bones." The approaches of the instructor also played an important part in making learning meaningful. If the instructor had good teacher approaches, it became critical for proper understanding of the material. She stated, "It's like a relationship, basically. It goes both ways. Like, you have to ask for help, but if a teacher sees that a student is struggling and really trying, they should be able to offer help."

Participant F's learning styles focused on repetition of material mainly through writing, but also included aspects of reading, visual learning and kinesthetic learning. These patterns were unchanged between interview one and two, but in the second interview it was revealed that details were important for Participant F in terms of understanding the material. She explained,

> Well, for this class, what I did is I got out my laptop, and then I would go through <Learning Website>, and then I would also go through the book, because sometimes the book was more detailed, sometimes it was excessively detailed, but it's how I truly learned.

Unfortunately, this was a weakness in the instruction provided by the science professor of the course she was taking, causing her to rely more upon the written textbook for the details she needed instead of the broad overview the instructor presented in the class.

Participant F's ideas about science and scientists were neutral to negative in her personal views and remained so for both sets of interviews. When asked about science she stated, "I just thought -- when you said that, I thought of planets, and then I went to NASA. Like that's what I thought of." When put into a larger social context, her views remained largely the same. She explained this by saying,

> I think most people dread taking science classes. Only because it's -- like I said earlier, it's a lot of information, and science always seems to be one of my hardest classes. Like, I know I suck at math, but science always seems -- maybe it's just for me, but I feel like science is hard for most people.

In the second interview, Participant F commented that science was not for her by saying, "I am never -- science has not been my forte. English and writing papers really have been my forte, so it's like science and math, my brain doesn't work that way."

For anxiety relief, Participant F relied only upon her study skills which were tied with her self-confidence, and some time for writing and repeating the material. However, many things interfered with her self-confidence, such as low grades, her feeling of having to do the work, and time pressures from the overwhelming schedule she had over the semester. She explained,

> I kind of forgot that this one was a five credit, and I was like -- so I just kept adding -- I was like, okay, I'll take math, English, sociology -- so physiology, math, English, sociology -- I'm missing one. Physiology, math, English, sociology. I think my worst experience was that I took too many credits, and I'm taking way too many credits next fall, but I'm just trying to get it done so that I can get to nursing school.

Participant F was the only student to not complete the science course over the semester of interviews due to a combination of personal issues and an overwhelming schedule. Her medical anxiety and depression also played a role and was likely eroding her self-confidence.

Participant G.

Participant G was a second semester college female with plans on entering a dental hygiene program after obtaining her bachelor's degree. She often switched schools before coming to college. She stated, "I like, switched schools a bunch when I was younger. I think I switched like seven or eight times." These schools were mainly religious in focus.

Her first interview showed anxieties such as social anxiety. She expressed, "I would say a little bit towards just like probably a little bit of social anxiety, just because of like switching schools a lot, like, I don't know, like you have to like, make new friends constantly." Specific sub-anxieties such as science classroom anxiety, and science test anxiety were seen. She explained these feelings,

> And so, everything is just so confusing to me, and anytime that I like, try like, taking another science course, like, I try so hard to focus and so hard to listen, so I can like, understand it, and it doesn't work. You're just graded on tests. Like it's not if you understand it, it's just like, here's a question, like this is the answer, but you don't understand the meaning behind it, you just like study for the answers, which I feel like is probably like the hardest thing about learning it, is because like, you can -- you could technically pass the class with zero understanding, or like, minimal understanding.

Both of these sub-anxieties persisted from the first interview to the second.

The major challenges faced by Participant G were those relating to time management. Participant G also directly linked the feelings of being overwhelmed to science classroom anxiety for her, something she pointed out in both interviews. She stated, "The memorization, and since it's -- I kind of feel like sometimes it's just like a different language." In addition, Participant G also tied teaching approaches to her anxieties, specifically when the approaches of the instructor were not good. She explained, "I don't think I had that great of a teacher. So, when I'd like -- when she taught it, I don't think I like grasped the concept of it." However, she states in both sets of interviews that good teaching approaches are critical for understanding of the material, as well as fostering meaningful learning. She stated,

> The slides, like having the slides online really helps, so like if I were to miss a class, because I get migraines a lot, so I miss a lot of class, and like, just being able to like, go through them, especially like before exams and stuff, because they help so much, and like just, I've noticed that printing out the slides help a lot too, because then I can just follow along, like, if the slide changes, or like, instead of having -- I've noticed like when I do print out the slides, and I'm not worried about like writing down everything that's on the slide, I just take like, additional notes and like, anything that you add, and that really helps, too.

Meaningful learning for Participant G focused mainly on items that related to her personal interests as well as those that demonstrated practical applications outside the classroom. To her, if the information did not tie to daily life, it was not truly meaningful to her. However, in the second interview, Participant G did make a correlation between stories being used as explanations and making the information more meaningful to her. She stated,

> I think for this it's kind of hard to like make meaning for it outside of class, unless like, it's kind of like trivia, just because it's so like factual, I guess. Like, things that aren't so factual, I think like are easier, like, any like English thing I think is like easier to apply to your life versus like physiology, because you're really just like learning about your body, so.

Participant G's motivations for learning came down to feelings of having to do these tasks in order to achieve a greater goal, which in her case, pertained to moving into a dental hygiene field. Interestingly, she argued that grades were more of a negative motivator for her and did not inspire her toward learning. She stated,

> If you have good grades, yeah, but if you don't, I feel like -- I don't know. It depends. Like, going through the semester, like halfway through the semester last year, I had -- I think I had like a C or maybe even a D in that class, and I was just like, wow, like I'm just not going to understand this.

Participant G's feelings about science and scientists in both sets of interviews were primarily negative in both personal and a larger societal context. For example, she stated,

> They pretend like they know what they're talking about, they have all the answers, when they're just like, you know, we're just guessing. They're like, we have an idea, but we don't know like everything.

Part of this view, she admitted, came from early teachers and the settings of her early education, which was primarily in religious settings. Despite working for a degree in the sciences, her feelings were mostly unchanged over the course of the semester.

Participant G's learning styles were wide and included; auditory, visual, kinesthetic, writing, reading, and repetition. These styles did not change between interviews one and two, but she did place a higher emphasis on study skills in the second interview. She stated,

> I guess I study differently. I don't put as much -- I don't want to say I don't put as much effort in, but for the exams, I definitely like, I really, really study for the exams, but for some of the quizzes, I think what also kind of ties into it is like, I work in the morning right before class, so I don't really have time to like kind of refresh what I already studied. So, like, if I do, I only have like five minutes to quickly like read over everything again, but I think like, I'm doing not that great on the quizzes, and the first

> exam, I know I didn't do that great on. The second one I did pretty good on. And then I don't know how I'm going to do on the next one.

Anxiety relief for participant G focused more on persistence in the work than anything else; however, she did rely upon a support system of family and friends. These support systems, specifically the friends, were of great help to her over the course of the semester and kept her moving forward throughout the year. She explained, "I just -- like, I'm not scared to do stuff by myself anymore. Like, I was going to drop out, because I didn't want to go here alone."

Participant H.

Participant H was a second-year female college student hoping to enter nursing school after the current semester. She did not talk about her high school experiences. She began college at a private institution in Iowa but was forced to return to Wisconsin due to the high costs of room and board. Twelve credits transferred between the private school and the current college she is attending and currently she is trying to catch up and get the required credits needed for her degree path. Participant H was medically diagnosed with anxiety and suffered from social anxiety, which she linked with poor learning experiences from previous school years. Specific sub-anxieties consisted of science test, and science classroom anxieties. For examples she stated, "More so like when it comes to testing, because I'm not very good at testing. But for science, I feel like there's a lot more memorization and details when it comes to testing." These persisted between interviews. Bad teacher approaches were linked with science classroom anxieties by Participant H. She explained,

> Yeah. But it also depends on like the professor or the teacher, because like if the teacher's like, doesn't make it fun, or like isn't entertaining to like talk to as like a person, then it's

kind of hard to talk to them in class. So, it all depends on the professor is what I guess it means.

Motivation for Participant H was attributed to feelings of having to perform the work in order to achieve her goals. Grades and GPA, for her, were seen as an important motivator; however Participant H also agreed that grades can both be positive and negative motivators for study. This was seen in both the first and second interviews. She stated,

> Yes. Because you need good grades. If you don't pass the class, you don't -- you can't go to the next level, like, you need to pass classes to move on. It could be both. Because if you don't pass, then you're bummed about it, and you've got to retake it, but if you do pass, it's like, sweet, don't have to do that again. Probably getting like a C or something. That bothers me.

Meaningful learning, on the other hand, was tied to both personal interests and practical use of the information. There was a direct tie to the approaches of the instructor made by Participant H, when she stated that good teacher approaches make learning more memorable. She gave the following example of this:

> "In middle school, my science teacher, we played with potassium, I think it was? Magnesium, and put it in water. And he put too much in it, and it exploded the entire like beaker thing, and the glass flew all over the room. And he was like, don't tell your parents about this. I'll never forget that. That was always -- I always found that funny.

Meanwhile poor communication on behalf of the teacher makes learning harder to understand and retain. In the second interview, Participant H stated that nothing taught over the semester really felt meaningful to her, and only had to be learned to progress in her degree.

Participant H's learning styles encompassed reading, visual, writing, kinesthetic, and audible learning; however, she placed special importance upon the idea of repetition. The learning styles emphasized in her second interview only showed visual, writing, and reading. She again placed special importance upon repetition in her study approaches by saying,

> It depends on like what's coming up in the class. If I have like a quiz, I'll just go over my notes, because those are like, the notes from the week before the class, because then that's typically what the quiz is on. But if it's like a test, then I'll go over all the notes that I've taken and look over all the pictures and stuff in my lab manual and all that.

The major challenges faced by Participant H were those of time management, tied directly to an overwhelming schedule in both academic and personal areas. She explained,

> Well, like, I have two jobs and I'm a full-time student, and I work -- I'm a bartender, and I work at a -- as a CNA at a nursing home, so I work two to ten at the nursing and then six to two on Wednesdays and Thursdays and Saturdays at the bar. So, I had like no time for anything. Especially like, studying for the exams, stressing out a lot, because like I have to study in between like, at the nursing like in between pages or meals, and then at the bar, I'd like study when it's dead, or don't study at all.

Participant H was promoted in her job during the semester and felt an increased pressure and anxiety from this as she worked during her classes.

Participant H's ideas about science and scientists were overall neutral in both personal and social aspects. She did not feel overly concerned about the topic other than how it applied to her degree progress and her aim in entering a nursing program. This neutral stance did not change between the first and second interviews. When asked about science she stated, "I think when somebody says scientists, I think I said Albert Einstein or something like that, for like science, I was thinking of like the human body, or wait, or like, chemistry."

For anxiety relief, Participant H took breaks from the material by playing games, watching T.V. or cooking meals. She expressed,

> Typically, I have to take like a break. Whether it's like playing -- like play a game on my phone for a half hour or watch an episode of some sort of show that I like. Just typically just what I do where I go make -- like, I eat a lot of eggs, so I make eggs a lot.

This was supplemented by her study skills, which involved constant quizzing and repetition of the material being covered. This gave her confidence and lowered her anxiety. Again, the special emphasis on repetition was made by Participant H, stating that she learned material best by repeating it. She stated, "I always -- like for starters, I'll write it out, and then I'll read it out loud to myself, and that sometimes helps. A lot, actually."

Group Findings

All of the participants were female, and 7 out of 8 of them were white. All students were in the traditional college age (18-24 years old). Three participants shared that they had been medically diagnosed with anxiety and depression while the other five stated they did not have a history of anxiety. Two of the participants were not enrolled in the sciences while the rest were actively seeking degrees either in a medical field or in biology specifically. Only one student did not complete the semester in which they were enrolled.

Among all of the participants, several common themes emerged from the interviews with two being major themes in common with all eight participants. The major two themes are science classroom anxiety and teacher approaches (either good or bad). Science classroom anxiety and teacher approaches were mentioned more than any other themes in all of the participant interviews.

Science classroom anxiety was the most common theme between all participants. All eight participants had science classroom anxiety and in some way all of them mentioned either the overwhelming nature of the science courses or of the vast terminology of the classes. This theme of being overwhelmed was constant with the participants, from either overloaded schedules or to feelings of just being overwhelmed by the information in the course overall. Putting aside overwhelming personal schedules, it shows that every student participating in this research felt as if the nature of science education itself is convoluted with its presentation of information.

Teacher approaches, either positive or negative, were the second most common theme expressed by all participants. Various examples of both good and bad teacher approaches were discussed by all students. The majority of participants felt that teachers who made active attempts to speak with, relate to, and interact with students on a personal level were seen as having good approaches. Teachers who avoided contact with students, who were underprepared or did not know the material, did not show interest in the class or the students, or who did not answer questions were seen as having poor teacher approaches. The impact of either good or bad teaching approaches greatly affected both meaningful learning and anxiety levels in the participants. The role of the teacher with imparting the information appears to have great significance in how students learn and feel about the course overall.

It is obvious that science classroom anxiety and teacher approaches are the critical themes that emerged from this study. No one common theme emerged for anxiety relief among the subjects, just as no one common theme emerged for emotional aspects causing participant ideas about science. Only one participant failed to complete the course over which the interviews were performed, but this was in part due to multiple factors, of which anxiety did play a role.

Summary

Among all eight participants two major themes emerged from the data and the concept maps. Science classroom anxiety was present among all participants, indicating that all of them felt as if the information presented in the science classes was overwhelming in some way. Teacher approaches, either good or bad, was a theme that was mentioned by all participants and each gave examples of how teachers either helped with learning and anxiety relief or denied meaningful learning and added to anxiety.

Chapter 5: Discussion and Implications

According to the perceptions of the eight participants in this study, teaching approaches along with the volume of information and how it is presented in science courses affects the levels of anxiety experienced by students. By looking deeply at the themes identified in this research and how they relate to one another educators can potentially understand how to address student anxiety over science and better attend to the emotional and learning needs of students entering these courses.

The two major themes to emerge from the interviews, concept maps, and response matrices were science classroom anxieties and teaching approaches. These themes were identified by all eight of the participants, and all participants appeared to be in agreement with each other in terms of how they were affected in their science courses. It is important to note that these students were all interviewed separately at different times and were unaware of who else was participating in the research so any collaboration on interview answers is highly unlikely. That being said, the two themes of science classroom anxiety and teaching approaches were not only mentioned multiple times by each participant, but the emphasis on each topic was similar between all participants.

As mentioned in the literature review, science anxiety itself can potentially be broken down into six subunits consisting of:

- danger anxiety (anxiety in response to a perceived threat),
- science test anxiety (anxiety in response to taking a test),
- problem-solving anxiety (anxiety in response to making a decision about a problem),
- squeamish anxiety (anxiety in response to something the subject is repulsed by),

- performance anxiety (anxiety in response to performing a task at which the subject feels inadequate),
- science classroom anxiety (anxiety in response to potential information overload) (Wynstra, 1991).

These sub-anxieties were found and researched in 750 high school students using a survey instrument designed to detect science anxiety (Wynstra, 1991).

Of all the science anxieties described by Wynstra's (1991), clearly one sub-anxiety came to the forefront for each participant in this study. Science classroom anxiety was prominent among participants more than any other sub-anxieties identified in Wynstra's work. Science classroom anxiety is defined by a feeling of being overwhelmed by the terminology or volume of information to be taken in and understood during a science course. From the data obtained from the eight participants in this study, science classroom anxiety was demonstrated as feelings of being overwhelmed by the classroom materials and not from sources outside the class. In addition, anxieties regarding the terminology involved in science courses were also combined into this sub-anxiety after coding and data analysis was performed.

This one sub-anxiety appeared often in all participants. This finding seems to agree with Tobias in her work, looking at science education in general (Tobias, 1990, 1992). The language used in many cases served as a barrier for those who were not involved or not science majors. This barrier being present even for students who were interested in scientific careers is an important note and speaks to the overuse of jargon terms and possible unconscious use of scientific language to weed people out of scientific areas. Many aspects of normal science education were seen as extremely off-putting, such as the singular use of lecture format teaching approaches, no real discussion sections, a distinct language barrier (i.e., scientific jargon), and feeling more of competition with other students (Tobias, 1990). Participant A stated: "In the setting of biology, because I can get the concepts, but not the vocabulary and stuff." Participant G pointed out one of her biggest challenges was, "Probably having to spend more time on it, just because, like… you kind of said, it's kind of like a foreign language."

All of the students interviewed were early in their college studies, either being second semester students or second year students. Six were interested in medical career paths after obtaining their bachelor's degrees, while two were taking the science course in question for credit in other areas of study. That science course anxiety appeared to be one of the major anxieties for all students demonstrates the degree that language and the amount of information presented in a course can be a major producer of anxiety for a student. That this feeling did not diminish over the semester between interviews also speaks to the severity of the anxiety source.

Today, science is primarily taught using behavioral pedagogical tools and theories leading to a "lecture and retain" teaching style. This lends itself to the feeling of easily being overwhelmed by the information, especially in the courses being taken by the participants in this study. Two of the participants were taking an introduction to biology course while the remaining six were taking a physiology course. Both of these courses cover an incredible amount of information and often teachers lament that there is too much to cover in a single semester.

The other issue here is that of technical language, something science has used since its inception as a field of study. This lends itself to a disconnect of the students from the material simply because of the difficulty in understanding what is meant by certain terms and phrases when used in lectures. It has been suggested in the past that the use of technical language was used as a way to keep some people out of the sciences (Tobias, 1990) while the field was being developed in early universities. However, this holdover of overly technical language now only serves as a barrier to students with its needless complexities.

Teaching approaches was the second most common theme expressed by all eight of the students interviewed. The theme teaching approaches represents either the positive or negative impact the instructor of the course had on not only imparting the material, but also how they interacted with, supported, and set the class climate for the students as a whole. Broadly speaking, teachers who had good teaching approaches communicated often with the students, actively made themselves available for questions or help, made the classroom a welcoming place, and found ways to relate the materials to either personal stories or made the information seem practical to know outside the classroom. Those instructors with poor teaching approaches lacked the positive qualities or did things to actively discourage questions, made the students feel uncomfortable, overloaded the students with information, and did not attempt to help the students understand the material. They simply presented the information.

In most of the interview's students commented that the teachers with positive approaches made the class much more approachable and made them more willing to work and understand the material. From the students' perspectives, there were direct links between aspects of meaningful learning and the actions of the instructors, such as using stories to explain a difficult concept, which was something previous research had shown as being a positive way to get students to understand difficult concepts (Hong & Lin-Siegler, 2012). Of critical importance was that students often linked anxiety relief with instructors who had positive teaching approaches or had found ways to work with students so that they understood the instructors' approaches to teaching.

Instructors who had negative approaches to teaching had a massive impact on the levels of anxiety of the students while taking the courses. In several interviews, poor teaching approaches such as not engaging with the students, reading directly from the textbooks, and not making the information understandable within a student's frame of reference were linked directly to certain types of anxieties for the students. From the student perspective, this made the classes harder for them to understand. In most cases, the students were able to find ways to cope with the anxieties, but they complained that the course was needlessly difficult because of the actions of the instructor.

As indicated in previous research (Tobias, 1990, 1992), the classic approaches of teaching science are not enough to help most students to truly understand the material. When this aspect of poor instructional approaches is combined with the already present science classroom anxiety, it only makes the material harder for the student to comprehend. It would be impossible to eliminate all anxiety over the material or the instructional approaches but by improving the way instructors provide the information it could ease the levels of anxiety already present.

One aspect contributing to science classroom anxiety, in particular, that combines with poor teaching approaches is the use of terminology. Students in this study often commented that the overly complex and technical jargon used by professors was one of the main points that caused them to fear the class. From the student's perception, language usage in combination with poor teaching approaches is one of the biggest causes of anxiety for students.

Only one student dropped out over the course of the semester, and this was due to a combination of personal life issues, as well as, anxiety related causes. The rest of the students interviewed persisted with the course they were taking over the semester. Unfortunately, this sample was too small to come to a conclusion about what anxieties affected the students enough to remain in or drop a course, but there are inferences we can make using the data obtained. The one student who dropped had lost her support system over the course of the semester and did not seek outside help in dealing with anxiety issues. She tried to rely upon her own self-confidence, which she readily admitted to having lost in several circumstances. In comparison, the remaining seven students who completed their courses all had outside tools to help them deal with their anxiety, and support systems of friends and family in place that could help them deal with emotional issues that arose over the semester. While the student who dropped the course did say it was partially due to anxiety issues, it was unclear if these anxieties were due to science anxiety or the medically diagnosed anxiety and depression she already had. We cannot rule out the possibility that science anxiety was a possible cause, but it was certainly not the only cause of her dropping the course. Even then, she remained resolute in her desire to obtain her nursing degree and would have to re-take the class at another time to meet the degree requirements.

The emotional factors that affected the views of students about science and scientists were highly varied, ranging from upraising, prior education and personal beliefs gained over time. There was no single root cause for the views of each student when it came to science and scientists, but overwhelmingly the main views were either neutral or negative feelings. While some students stated they had positive feelings about science or scientists, most of the examples given on these topics were single stories about some particularly entertaining moment that caught the students' attention. Broadly, most of the thoughts about science were neutral, as it was important but in a vague way, or negative in that the material was exclusionary to people or even malicious in some ways. That these ideas remained largely unchanged between the interviews over the course of the semester may reflect how deeply ingrained these ideas about science are for these individuals. At this stage of their lives, many biases are already set, and it can be difficult to change these predispositions towards science and scientists.

That is not to say that these feelings cannot change at all, but that the information about science and scientists needs to be integrated within the students' worldviews. Knowledge is constructed and needs to be integrated into a person's frame of reference for it to be meaningful. To change long standing beliefs or biases the new information must be able to challenge old perceptions and still integrate within a student's knowledge framework. One semester may not have been enough time to see such a shift in a student's perceptions about science.

The techniques used to relieve anxiety for each of the students varied for each individual with some amount of success or failure. As mentioned earlier, only one student failed to complete the science course they were enrolled in over the semester of interviews, and that student did not have many tools to deal with her anxieties. The others relied upon a wide variety of tools to help them deal with their situations, from certain places and sounds, activities and support systems of friends and family. The tools used to deal with anxiety were as varied as the individuals dealing with the issues. What is important to note here is that regardless of the tools used to deal with the levels of anxiety that each student encountered, they all experienced the same or similar type of science anxiety. The tools to treat the anxiety differed, but the source of the anxiety remained the same.

The implications of this research connect with some of the core complaints about how science is taught (Tobias, 1990, 1992) and how well teachers are trained in terms of presenting the subject matter (Epstein & Miller, 2011). One major issue in science education is the fact that in the upper levels of academia, one only needs a Ph.D. in the subject matter to be qualified to teach the material. This has been an issue because it is assumed that just because someone has a

Ph.D. in a science subject, they can teach the information. This is most often untrue, as being an expert in an area of knowledge does not necessarily mean that someone has the skill to pass the information on to others. Those skill sets are not contiguous, and in many cases exist as separate traits in educators. Given that the primary science anxiety encountered in this study was one of science classroom anxiety and the problem of teaching approaches in presenting the material was the second most commented on theme by the participants, this suggests a two-part situation where the information itself is overwhelming and it requires the approaches of a good educator to be able to pass on the information effectively. This appears to be a problem with the current methods of college instruction for this group of students.

Being an expert in an area of research is obviously important when it comes to understanding the material, but it is something else entirely to be able to pass that information on in ways students can understand and utilize. Researchers have identified that an expert teacher can pinpoint the most important ways to present the content they teach (Hattie, 2012). This means that while the instructor knows the material, it is more important know and be able to present the material to the students. Most of the participants in this study stated that meaningful learning for them was comprised of factors that related to their personal interest, demonstration of practical applications, and use of stories to make the material understood beyond just a technical format. These approaches of education require much more than a lecture and retain approach of teaching, which is something that is not commonly done in most areas of science education (Tobias, 1990, 1992). Simply put, it is one thing to study and research a field of science, it is something else entirely to be able to stand in front of people and successfully be able to talk about the area of research in an understandable manner. This means that to truly be able to impart information successfully to a student an instructor needs to have the skills of an educator in addition to the skills relevant to their field of study.

In addition, because all of the students in this study were women, the literature indicates that there exists a gender bias against them entering the sciences in general adding to their levels of anxiety in taking the courses. This bias has existed for some time causing women to avoid the sciences in general despite there being no real cognitive difference in science ability between men and women (Stoet & Geary, 2018). Six of the eight participants in this study were entering into life sciences, either biology or medical related areas, and yet they still experienced high levels of anxiety as seen in their responses to the interviews over the semester. Again, all eight students reinforced each other's statements that the way information was presented in the class and the approach of the instructor were the major influences of anxiety for them. Unfortunately, at the time of the interviews the gender of the instructors teaching the classes was not known. This would be an interesting follow-up question to ask in future research, determining if and how the instructors gender impacted the anxiety levels felt by participants.

Implications for Teaching

It is important to note that all the information about teaching approaches and the amount of information presented in the courses came entirely from the perspectives of the students participating in the research. Without witnessing the teaching of the classes or observing the teaching approaches used in the courses we only have the information from the point of view of the participants involved. All eight participants did share similar perspectives on the effects of teaching approaches and the overwhelming nature of the subject material being presented.

Results of this study indicated that from the students' perspectives good teaching approaches are needed in the sciences. From this perspective, good teaching approaches implies the need for additional education and training of instructors in the skills they need to be able to successfully speak to people. Additionally, from the participants' point of view, training in how best to get points across to students appears to be needed. Therefore, from the perspective of the students involved in this study, professional development for college professors should include more than just studying the research discipline. Professional development should include andragogical preparation into the theories of meaningful learning, along with coaching on how to respond to the needs of the students. These are teaching approaches that have been shown to have an impact on pre-college levels of education (K-12) and could easily be applied to college levels (Hattie, 2012). Both of these teaching approaches could be developed as a necessary part of the skill sets of college professors designed to stem the tide of students leaving science courses or failing to succeed in them.

For educators to truly facilitate student understanding and learning, it becomes critical that they communicate with not only their students, but also with their peers to gauge how they are performing (Hattie, 2012). In communicating with peers, levels of achievement should be discussed, ways to engage with the students planned, and working with each other to make the language used understandable. By working with students on a more personal basis the communication of ideas becomes easier and it becomes possible to pinpoint areas where students are not understanding topics. By understanding what a student brings to a class from prior learning, a teacher can much better prepare how to present new information (Hattie, 2012).

In science courses the information can be overwhelming, and the language can be technical and laden with jargon, but good instructors know how to emphasize the core elements of the information being presented and impart the knowledge in ways that students can comprehend. This could be a major shift in how instructors are chosen to teach certain areas of science education. From the perspective of the participants involved with this study the shift here should involve a focus on how the student learns versus how the instructor teaches.

In addition, as seen from the points of view from each of the participants, it is highly recommended that teachers spend more time trying to make connections to their students in order to make the information either personally relevant or practically applicable to their lives. This is especially true in college level courses, where students often feel disconnected from the information being presented. In order for students to truly understand the information, a connection should be made to either their personal interests or to show that the information has practical application in the outside world. A teacher cannot rely upon the information standing on its own to seem important but must put the information in context. This approach of teaching has already been shown to be effective in teaching students and should be applied in colleges (Arya & Maul, 2012).

Implications for Future Research

Understanding student anxieties and the impact on learning is an important research area. Suggestions for future research in this area include the following ideas.

Additional research could include a broadening of the sample selection process to find individuals who may have varying levels of science anxiety. This could be accomplished using a team of researchers canvassing multiple campuses with the initial selection survey versus working with one campus at a time. This approach could potential increase the sample size of participants in the research.

Additionally, this study could be replicated for a much younger student population such as in K-12 grades. This suggestion is based on statements from participants in this study where they mentioned that younger students seem to have no fear of science and that they even loved the material when they were younger. It would be interesting to see how if and how these anxieties develop and change over time

When this research was initially proposed, I anticipated that my sample would consist of a more equal balance of students from both genders. To my surprise, even though I did find male participants that had science anxiety, none of them were willing to participate in the interview process. All of the participants in this study were female. In future research, by increasing the size of the initial selection pool of participants, I believe that a more diverse sample could be obtained.

It would also be of interest to observe the gender representation of the instructors of the science courses participants were taking. It would be interesting to see if having a male or female instructor could have an effect on the anxiety experienced by the students in the course.

Lastly, a longitudinal study addressing how particular teaching strategies affect levels of student anxiety could provide valuable information. If certain teaching approaches alter how students perceive a course, it would be valuable to learn what specific approaches could be fostered in educators to reduce science anxiety.

Limitations

The major limitations of this initial research were the size and homogenous nature of the sample. It would have been preferable to have a larger and more diverse group of participants, but it is believed that the initial results provide a beginning understanding of science anxiety. Because the two major themes, science classroom anxiety and teaching approaches, persisted across all of the participants, it appears that these findings are significant in their implications for this research. It was shown in previous research that female students tend to disengage from science courses more often ("Disengage" 2010) and this may have been an issue with some of the results gathered.

In addition, the initial sample size for this research was only eight individuals and initially it was hoped that ten to fifteen participants would be found. The problem here was the sampling size and the efforts of only one individual to find sufficient willing participants in this initial study.

Summary

Two themes emerged from the data in this study: science classroom anxiety was suffered by all participants and teaching approaches were an important contributor to how students learned and how their anxiety levels were affected over the course of the class. With these themes, implications for teaching science were suggested, as well as, ideas for future research. Limitations of the study were also discussed.

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APPENDICIES

Appendix A: STASci-36: Survey of Attitudes toward Science

Pre

DIRECTIONS: The statements below are designed to identify your attitudes about science. Each item has 7 possible responses. The responses range from 1 (strongly disagree) through 4 (neither disagree nor agree) to 7 (strongly agree). If you have no opinion, choose response 4. Please read each statement. Mark the one response that most clearly represents your degree of agreement or disagreement with that statement. Try not to think too deeply about each response. Record your answer and move quickly to the next item. Please respond to all of the statements.

	Strongly disagree			Neither disagree nor agree			Strongly agree
I plan to complete all of my science assignments.	1	2	3	4	5	6	7
I plan to work hard in my science course.	1	2	3	4	5	6	7
I will like science.	1	2	3	4	5	6	7
I will feel insecure when I have to do science problems.	1	2	3	4	5	6	7
I will have trouble understanding science because of how I think.	1	2	3	4	5	6	7
Science formulas are easy to understand.	1	2	3	4	5	6	7
Science is worthless.	1	2	3	4	5	6	7
Science is a complicated subject.	1	2	3	4	5	6	7
Science should be a required part of my professional training.	1	2	3	4	5	6	7
Science skills will make me more employable.	1	2	3	4	5	6	7
I will have no idea of what's going on in this science course.	1	2	3	4	5	6	7
I am interested in being able to communicate scientific information to others.	1	2	3	4	5	6	7

	Strongly disagree			Neither disagree nor agree			Strongly agree
Science is not useful to the typical professional.	1	2	3	4	5	6	7
I plan to study hard for every science test.	1	2	3	4	5	6	7
I will get frustrated going over science tests in class.	1	2	3	4	5	6	7
Scientific thinking is not applicable in my life outside my job.	1	2	3	4	5	6	7
I use science in my everyday life	1	2	3	4	5	6	7
I will be under stress during science class.	1	2	3	4	5	6	7
I will enjoy taking science courses.	1	2	3	4	5	6	7
I am interested in using science.	1	2	3	4	5	6	7
Science conclusions are rarely presented in everyday life.	1	2	3	4	5	6	7
Science is a subject quickly learned by most people.	1	2	3	4	5	6	7
I am interested in understanding scientific information.	1	2	3	4	5	6	7
Learning science requires a great deal of discipline.	1	2	3	4	5	6	7
I will have no application for science in my profession.	1	2	3	4	5	6	7
I will make a lot of errors in science.	1	2	3	4	5	6	7
I plan to attend every science class session.	1	2	3	4	5	6	7
I am scared by science.	1	2	3	4	5	6	7
I am interested in learning science.	1	2	3	4	5	6	7

Strongly Neither disagree Strongly

	disagree			nor agree			agree
I can learn science.	1	2	3	4	5	6	7
I will understand science equations.	1	2	3	4	5	6	7
Science is irrelevant in my life.	1	2	3	4	5	6	7
Science is highly technical.	1	2	3	4	5	6	7
I will find it difficult to understand scientific concepts.	1	2	3	4	5	6	7
Most people have to learn a new way of thinking to do science.	1	2	3	4	5	6	7

Please notice that the labels for each scale on the rest of this page change from item to item.

How well did you do in scientific courses you have taken in the past?	Very poorly 1	2	3	4	5	6	Very well 7
How good at science are you?	Very poor 1	2	3	4	5	6	Very good 7
In the field in which you hope to be employed when you finish school, how much will you use science?	Not at all 1	2	3	4	5	6	Great deal 7
How confident are you that you can master introductory science material?	Not at all confident 1	2	3	4	5	6	Very confident 7
Are you required to take this science course (or one like it) to complete your degree program?	Yes 1			No 2			Don't know 3
If the choice had been yours, how likely is it that you would have chosen to take any course in science?	Not at all likely 1	2	3	4	5	6	Very likely 7

DIRECTIONS: For each of the following statements mark the one best response. Notice that the response scale changes on each item.

What is your major? If you have a double major, pick the one that bests represents your interests.

1. Arts/Humanities
2. Biology
3. Business
4. Chemistry
5. Economics
6. Education
7. Engineering
8. Mathematics
9. Medicine/Pre-Medicine
10. Psychology
11. Sociology/Social Work
12. Statistics
13. Other

Current grade point average (please estimate if you don't know; give only one single numeric response: e.g., 3.52). If you do not yet have a grade point average, please enter 99: _____________

For each of the following three items, give one single numeric response (e.g., 26). Please estimate if you don't know exactly.

Number of credit hours earned toward the degree you are currently seeking (don't count courses from this semester): _____________

Number of high school science courses completed: _____________

Number of college science courses completed (don't count this semester): _____________

Degree you are currently seeking:

1. Associate
2. Bachelors
3. Masters
4. Doctorate
5. Certification
6. Post-bachelor's Licensure
7. Specialist
8. Other

What grade do you expect to receive in this course?

1. A+
2. A
3. A-
4. B+
5. B
6. B-
7. C+
8. C
9. C-
10. D+
11. D
12. D-
13. F

In order to describe the characteristics of your class as a whole, we need your responses to the following items.

Your sex: 1. Male 2. Female

Your age (in years): _____

THANKS FOR YOUR HELP!

Appendix B: Literature Reviewed Table

Author and Year	**Section Relevance**	**Purpose**	**Findings**
“Disengage” 2010	Science Education Today	Research into high school females in science and their engagement in the courses	Findings show that more females disengage from science courses and only inclusion of more discussion sections seems to alleviate the problem.
“Math Anxiety” 2011	Science Education Today	Research into the neural patterns of students having anxiety about certain subjects	Overcoming anxiety for a subject had much less to do with what you know, and more about convincing one that the task can be done.
“NIH Science Education Nation” (No Date)	Science Education Today	Detailing the history of science education reformations	History of science education reformations
“What is Contextual Learning?” 2012	Emotions, Anxiety, Framework and Meaning	Definitions and explanations of Contextual Learning	Clarification of points and help in defining terms

Author and Year	Section Relevance	Purpose	Findings
Arya & Maul, 2012	Science Education Today	Research into the importance of context in scientific learning	The addition of context and the emotional aspects of those involved in science had a profound effect on the students' ability to understand the information.
Ausubel 1963	Emotions, Anxiety, Science Education Today, Framework and Meaning	Book: Explanation of meaningful learning theory, its uses, and mechanics	This served as a foundation for Novak's work and further defined the theories of meaningful learning.
Bloom 1981	Emotions and Anxiety	Established "Domains" of education	Defined the cognitive, affective, and psychomotor domains of education today
Bui & Alfaro 2011	Science Education Today	Research into personal attitudes on a subject and how they affect a student's anxiety	The development of a positive attitude toward science early on in education may be critical in overcoming statistics anxiety later on in a student's academic career

Author and Year	**Section Relevance**	**Purpose**	**Findings**
Clark &Dirkx 2008	Emotions and Anxiety	Research into emotional self's role in education	Showed that emotions are critical for proper motivation of students
Daston 1998	Emotions and Anxiety	Research into imagination and its purpose in scientific research	Showed most scientists ignore emotions or imagination
Dirkx 1997	Emotions and Anxiety	Research into emotional self's role in education	Showed that emotions are critical for proper motivation of students. Emotions must be shown both by students and instructors
Dirkx 2006	Emotions	Research into emotional self's role in education	Showed that emotions and imagination are critical for proper motivation of students
Dirkx 2006	Emotions	Research into emotional self's role in education	Showed that emotions are critical for proper motivation of students, added Jungian context and connections to transformative learning

Author and Year	**Section Relevance**	**Purpose**	**Findings**
Dirkx 2008	Emotions, Anxiety, Framework and Meaning	Research into emotional self's role in education	Showed that emotions are critical for proper motivation of students
Ediger 1997	Emotions, Anxiety, Framework and Meaning	Research into the affective domain in science education	Showed that emotional learning as defined by bloom's affective domain is indeed important for true comprehension of a subject.
Epstein & Miller 2011	Science Education Today	Research into the ability of teachers to enact STEM protocols	Many teachers feel ill prepared to teach science, resulting in anxiety about the subject for both them and their students.
Hattie 2012	Implication	Explaining the tools needed by educators to teach students	This work lines up with the findings in the implication section, especially with the demands of students for better interactions with instructors
Hertig 1976	Science Education	Call for biology teachers to	This call was the motivation

	Today, Framework and Meaning	radically reform their education methods and styles	for Novak's work in meaningful learning, especially in the sciences
Author and Year	**Section Relevance**	**Purpose**	**Findings**
Hinds 1999	Emotions, Anxiety, Science Education Today	Research into the special needs of adult learners	Shows that adult learners need motivation, emotional attachments, and proper context for information to be relevant
Hodges 1997	Emotions and Anxiety	Research into self-esteem and it's use in the classroom	Showed that lack of confidence or self-esteem can cripple students' ability of comprehension .
Hong & Lin-Siegler, 2012	Science Education Today	Research done to see if adding historical context of scientists struggles to understand material helps students make meaningful connections	Students did indeed show increased comprehension of material presented when the background information and struggles of the scientists responsible for the work done was presented in the text.
Hussenius 2014	Gender in Science Education	Historical perspectives of gender in science education	Showed the current research and concerns about gender in

			science education
Hurd 1985	Science Education Today	Call for making contextualized learning a part the sciences	An appeal to put science in context with the daily lives of students.
Author and Year	**Section Relevance**	**Purpose**	**Findings**
Jung 1969	Emotions and Anxiety	Textbook, Definitions of emotions and emotional states	This is one of the psychological foundations in people.
Kerkhoven, A.H., Russo, P., Land-Zandstra, A.M., Saxena, A., & Rodenburg, F.J. 2016	Gender in science education	Looking at gender stereotypes in science education	Found visual representation of science information heavily biased towards male images
Krange & Arnseth, 2012	Framework and Meaning	Research into meaning making by students using technology	Found that students can make meaning of abstract data when supplied with proper instruction and tools
Krathwohl, Bloom, &Masia 1973	Emotions and Anxiety	Further research into Bloom's domains of education	Refinement of domains into more commonly used forms.
Kuhn 1996	Science Education Today	Book: Definitions of what science and scientific research is based upon philosophical thought	This work re-defined the reasons why researchers do science and explains how dogmas and paradigms are altered in scientific thought

Meizrow 2000	Emotions, Anxiety, Framework and Meaning	Book: Explanation and examples of transformative learning and its uses	This serves as a foundation for the learning theory behind this research
Author and Year	**Section Relevance**	**Purpose**	**Findings**
Merriam, Caffarella, & Baumgartner, 2007	Framework and Meaning	Textbook: Used to help define and expand certain terms and philosophical arguments for this thesis	This was used as the starting point for the theories and ideas behind this research
Milner, Sondergeld, Demir, Johnson, & Czerniak, 2012	Science Education Today	Research into the beliefs of schoolteachers teaching science in a post NCLB environment	Lack of support for instructors as well as students radically effects student achievement in the sciences.
Newall, C., Gonsalkorale, K., Walker, E., Forbes, G.A., Highfield, K., & Sweller, N. 2018	Gender in science education	Research into the perceptions of adults when presented with differing genders of science students	Found the presented gender affected the adult's belief in how well a student could perform in a science course.
Novak & Gowin 1984	Emotions, Science Education Today, Framework and Meaning	Book: Explanation and examples of Meaningful Learning, its uses, and mechanics of concept maps as learning tools	This work defined meaningful learning for the research proposal and how it was to be viewed.

Author and Year	Section Relevance	Purpose	Findings
Novak 1998	Emotions, Anxiety, Framework and Meaning	Book: Explanation and examples of Meaningful Learning, its uses, and mechanics of concept maps as learning tools	Update of an earlier work (see above)
Orlander &Wickman, 2010	Framework and Meaning	Research into how science can be made meaningful to students	Students who discussed the material with each other and the instructor were able to make the most meaning from the lesson
Otero, Leon, &Graesser, 2002	Science Education Today	Research into student use of science textbooks	When it comes to most science textbooks used in education, students find them overly serious and un-motivating
Rowlands 2001	Science Education Today	Research into children's biological understanding	Found that most research done in science education focuses on achievement over any other aspect
Shermer 1998	Science Education Today	Research into children's biological understanding	Found that most research done in science education focuses on achievement

			over any other aspect
Author and Year	**Section Relevance**	**Purpose**	**Findings**
Sikora, 2015	Gender in science education	Looking at the gender divide in science education	Males and females have the same levels of science capabilities but divert into separate areas of research along gendered lines.
Stoet & Geary, 2018	Gender in science education	Looking at the Gender-Equality paradox	Gender-equal countries have more gender-bias in STEM fields
Tobias & Tomizuka, 1992	Framework and Meaning	Book: Work done to explain, understand, and get into the sciences for normally non-science majors	Provides context for science, science education, and culture for non-traditional science students afraid of science.
Tobias 1990	Science Education Today	Research into science course culture and structure as seen by non-majors	Found that the environments are not conducive to adult learning, especially for those who consider themselves "outside" the sciences.
Tobias 1992	Science Education Today, Framework and Meaning	Research into science education revitalization and why many efforts fail	Students have a disconnect from the material covered. No attempt to

			make it meaningful to the students
Author and Year	**Section Relevance**	**Purpose**	**Findings**
Usera, 1984	Science Education Today	Research and assessment of science anxiety levels in students	Students dealing with high anxiety levels in a subject will often view the subject as a threat
Wynstra, 1991	Science Education Today	Research and definition of different types of learning anxieties	Science anxiety as a whole is sometimes discounted and blamed on poor background knowledge of the information by the student, many cultural and societal myths surrounding science, poor teaching of science, and anxiety felt by the teachers in regards to teaching science

Curriculum Vitae

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Education:

Graduate Level Research, Microbiology and Molecular Biology, Loyola University, Maywood IL, 2005

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Academic/teaching Experience:

- Anatomy and Physiology
- Education and Education Theory
- General biology for majors and non-majors
- Molecular biology
- Ecology and Evolution
- Cell biology
- Developmental Biology
- Animal Anatomy
- Limnology
- Botany
- Biological aspects of conservation of natural resources
- Environmental Biology
- Zoology
- Human Sexuality

Teaching responsibilities:

- Teaching undergraduate students
- Preparation of quizzes and lectures
- Grading and evaluation of laboratory reports
- Student advisement and mentoring
- Office hours and tutoring (14+ hrs per week)
- Preparation of laboratory material and equipment
- Organization of field exercises for an urban ecology course
- Mentoring of laboratory personnel

Courses Developed:

- Created General Biology course from ground up for UW-Sheboygan
- Created Developmental Biology laboratory and lectures for DePaul University

- Created new Ecology of wetlands lectures for Environmental Course at UW-Sheboygan
- Developed New Material for Biology of Human Sexuality at UW-Sheboygan
- Developed Biology of Frankenstein lectures for non-science majors for LEC 100 series for UW-Colleges

Research Experience:

Graduate Research Assistant, Loyola University, Maywood, IL, 2005
Project: Analysis of a key morphogenetic protein in spore coat assembly

- Vector construction and cloning of genes
- Protein overproduction and purification
- Culture growth and maintenance
- Gel electrophoresis for DNA including Gel Shift assays
- SDS PAGE, Western, and Far Western analysis
- Two-Hybrid analysis
- Gel Filtration Chromatography
- *in vitro* and *in vivo* immuno-precipitation
- Fluorescence microscopy and immuno- fluorescence microscopy

Graduate Research Assistant, DePaul University, Chicago, IL, 2000
Project: Conserved gene expression in vertebrate skulls and shells: msx gene family in turtle development.

- cDNA library construction
- Paraffin wax histology
- *in situ* hybridization
- Tissue preparation and Staining
- Laboratory animal control

Publications

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Browning DF, Beatty CM, Sanstad EA, Gunn KE, Busby SJ, Wolfe AJ., Modulation of CRP-dependent transcription at the Escherichia coli acsP2 promoter by nucleoprotein complexes: anti-activation by the nucleoid proteins FIS and IHF. Mol Microbiol. 2004 Jan;51(1):241-54.