BENEDICTINE UNIVERSITY

A PHENOMENOLOGICAL STUDY: MOTIVATION AS EXPERIENCED BY ENGINEERING DESIGN COMPETITORS AT A SELECTIVE ENGINEERING UNIVERSITY

A DISSERTATION SUBMITTED TO THE GRADUATE SCHOOL IN CANDIDACY FOR THE DEGREE OF DOCTOR OF EDUCATION IN HIGHER EDUCATION AND ORGANIZATIONAL CHANGE

BY

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LISLE, ILLINOIS

APRIL, 2014
ACKNOWLEDGMENTS

Arriving at this dissertation has taken a lifetime of educators and supporters. The people listed here are but a sampling of the amazing individuals who have influenced my lifetime of learning.

To my mother, Linda M. Lloyd, who served as my reading coach, tutor, and biggest fan, all roles she still holds to this day. To my mom and the rest of my immediate family Tom, Rebecca, Adam, and Pam, your support and love is always with me. To my extended family and friends, especially Dr. Robert Lopez, Dr. Joshua Thiry, Blue Star, and hundreds of others, your friendship has sustained me and kept me going through the toughest times. To my brothers in Delta Upsilon, thanks for always checking in on my progress and helping me to remember Dikaia Upotheke.

To my fellow Ed.D. candidates who have been my rocks, ensuring that I never gave up, especially to Lisa Greenhill, and Jenni Hesterman. To Catherine Grandizio, for listening to me read aloud from my dissertation and for allowing me to bounce numerous ideas off you. A special thanks to Caroline Day for giving of your proofreading talents and making sure that I know a sentence should not start with the word “and.” To the faculty, staff, and administrators at my university, especially Dr. Richard Heist, for believing in me and going out of your way to ensure that I had the tools and resources to move forward.

In addition to these important people in my daily life, some very influential and
dedicated people have come and some have gone, but they will never be forgotten. To Daniella Feuerstein and Diane Daub, two of the most influential friends, supervisors, and supporters. The two of you are the reason that I developed a work ethic and take pride in what I do. In addition, I shall forever be grateful to Dr. Robert M. Bishop, my Optometric Physician, who some 32 years ago convinced an eight year old boy with an eye problem that his circumstance did not make him stupid.

To my chair and committee: Dr. Nancy Bentley, Dr. Nancee Bailey, Dr. Joanne DeTore, and Dr. William Graham your guidance, support, and challenges have lead me on one of the most fulfilling and reflective educational journeys of my life. Each step of the way was met with kindness, encouragement, and an ever-watchful eye to ensure that this study was the best it could possibly be.

Finally, to the eight young men who served as my participants and co-researchers, your motivation to learn and dedication to your passions have been an inspiration and the very foundation of this study. I have learned so much about motivation, inspiration, and learning because of you. Through our journey together, I have become a better educator.
DEDICATION

To all those who are told you cannot, show them you can.
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ABSTRACT

This study focuses on the life experience of motivation for competitors of the International Robosub and Roboboat Competitions from a selective engineering university. A phenomenological study, using in-depth interviews and document/artifact analysis, was conducted. The competitors’ responses were analyzed to answer the research question which follows: while preparing for and participating in International Robosub or Roboboat Competitions, what experiences – actual acts, specific behaviors, or other moments – brought about motivational responses for student contestants? The results of the study are intended to provide educators with a better understanding of how to use engineering competitions in a way that will motivate their students to learn the design process. In addition, their responses provide educators with further insight on student motivation and the effectiveness of learning-centered education such as experiential learning, collaborative learning, and project-based learning.
CHAPTER 1

INTRODUCTION

“Education is not the filling of a pail, but the lighting of a fire.” ~ William Butler Yeats

Statement of the Problem

In 1970, Paulo Freire published one of his first of many critical essays on the state of education arguing that faculty-centered approaches lead to “an act of depositing, in which students are depositories, and teachers are depositors. Instead of communicating, the teacher issues communiqués and makes deposits which the students patiently receive, memorize, and repeat” (Friere & Friere, 2004, p. 72). Friere’s criticism of this technique, which came to be known as the banking method of education, is that students, as passive receptacles, do not actually comprehend what they receive:

They do, it is true, have the opportunity to become collectors or cataloguers of the things they store. But in the last analysis, it is the people themselves who are filed away through the lack of creativity, transformation, and knowledge in this (at best) misguided system . . . Knowledge emerges only through invention and re-invention, through the restless, impatient, continuing, hopeful inquiry human beings pursue in the world, with the world, and with each other. (Friere & Friere, 2004, p. 72)

The banking method of teaching has persisted and is often referred to as faculty-centered pedagogy. One example of faculty-centered pedagogy, the lecture, is characterized by a person of authority reading or speaking aloud from published works, notes, or their memory while students attempt to memorize the information. The pedagogy is further marked by a student being required to regurgitate the information during a test, quiz, or other form of assessment. Research into this one-way interchange shows that it often promotes shallow learning (Bransford, Brown, & Cocking, 2000) and fails to promote motivation to learn, confidence in one’s abilities to learn, and enthusiasm for learning
Freire is neither alone in his criticism of the banking method, nor was he the first to share deep concern that students are not learning optimally from this imposed pedagogy.

English philosopher John Locke in his work, *An Essay Concerning Human Understanding*, laid out his belief that humans are born with an empty mind, or clean slate, that can only be filled through having, feeling, and reflecting on experiences rather than the more common lecture-based pedagogic methodology of the day:

> Let us then suppose the mind to be, as we say, white paper, void of all characters, without any ideas: -- How comes it to be furnished? Whence comes it by that vast store which the busy and boundless fancy of man has painted on it with an almost endless variety? Whence has it all the materials of reason and knowledge? To this I answer, in one word, from EXPERIENCE. In that all our knowledge is founded; and from that it ultimately derives itself. Our observation employed either, about external sensible objects, or about the internal operations of our minds perceived and reflected on by ourselves, is that which supplies our understandings with all the materials of thinking. These two are the fountains of knowledge, from whence all the ideas we have, or can naturally have, do spring (1690, para. 2).

Prevalent author and educator Jean-Jacques Rousseau, who is credited as being one of the foremost minds of naturalism and education, and a forefather of both experiential learning and learning-centered pedagogy, rejected what he considered coercive educational practices. Instead, Rousseau called for organic and naturalistic learning outside the classroom. He was also quite critical of the use of stern authoritarian teaching, instead advocating for what Gutek (1988) called permissiveness, an early form of learning-centered teaching:

Rousseau’s *Confessions* show him to be a proponent of permissiveness, a theme also pursued in *Émile*. Rejecting the stern authority of the coercive teacher, Rousseau, who himself was frequently in trouble with authority figures, usually escaped from them. The character of Émile was his own authority, a person who either enjoyed or suffered the consequences of his actions, rather than subject
himself to another’s authority. Teachers, in Rousseau’s style, are permissive individuals who learned with their students. (Gutek, 1988, p. 65)

Later medical physician and educational practitioner Dr. Maria Montessori went even further in her criticism of what she considered oppressive educational techniques:

We know only too well the sorry spectacle of the teacher who, in the ordinary schoolroom, must pour certain cut and dried facts into the heads of the scholars. In order to succeed in this barren task, she finds it necessary to discipline her pupils into immobility and to force their attention. Prizes and punishments are ever-ready and efficient aids to the master who must force into a given attitude of mind and body those who are condemned to be his listeners. (1912, p. 21)

Each of these early educators share one important theme: students must be connected and interested in what they are learning. As Montessori points out, students cannot be forced into learning they must be an engaged and involved participants in their own learning.

In addition to these historic educational figures, many contemporary educators continue the call for the replacement of this faculty-centered methodology with a learning-centered approach. Benefits of the learning-centered approach include the following: more efficient and effective learning (Gibbs, 1981; Barr & Tagg, 1995; Mills & Treagust, 2003); better delivery of skills that support inquiry and knowledge discovery (O’Banion, 1997); broader student experiences, stronger problem solving skills, and abilities to interpret data (Landis et al., 1998; Fried, 2006); and a deeper understanding of important subject matter (Bransford et al., 2000); and motivation to learn (Nor, 2008).

Another contemporary researcher, Malcolm Knowles (1980), who is the father of the andragogy theory, believed that this didactic or faculty-centered approach was actually part of a continuum of instruction with faculty-centered (pedagogy) on one end of the spectrum and learning-centered (andragogy) approaches on the other side of the
spectrum. In the beginning of Knowles’ time as a researcher, he believed that pedagogy and andragogy were competing concepts, but he, like Dewey (1938) before him, eventually came to believe that pedagogy was appropriate for children or in teaching subjects where the adult learner needed to be led through the subject matter. As his thinking evolved, Knowles deduced that andragogical techniques were more appropriate for adult learners and subject matters that lend themselves to self-direction (Hiemstra & Sisco, 1990). In his book, *The Modern Practice of Adult Education from Pedagogy to Andragogy*, Knowles (1980) states:

One problem was that pedagogy was premised on a conception of the purpose of education—namely, the transmittal of knowledge and skills that had stood the test of time—that adult learners seemed to sense was insufficient. Accordingly, their teachers found them to be resistant frequently to the strategies that pedagogy prescribed including fact-laden lectures, assigned readings, drills, quizzes, rote memorizing, and examinations. Adults appeared to want something more than this, and drop-out rates are high. (p. 40)

As the words of Knowles show, he was extremely critical of utilizing pedagogical techniques, and, instead, advocated for experiential techniques and practical applications.

Unfortunately today’s engineering programs, like most disciplines, still utilize a number of these faculty-centered approaches.

The dominant pedagogy for engineering education still remains ‘chalk and talk’, despite the large body of education research that demonstrates its ineffectiveness. In recent years, the engineering profession and the bodies responsible for accrediting engineering programs have called for change. (Mills & Treagust, 2003, p. 2)

Even though “chalk and talk” methods are still prominent, many undergraduate engineering educators have heeded the call for change and adopted a number of learning-centered methods including: undergraduate research programs (Boyer Commission, 1998); just-in-time teaching (Novak, 2011); and discovery learning (Layng, Twyman, &
Stikeleather, 2004). Another learning-centered approach, engineering design competitions (Ellis, Rudnitsky, & Scordilis, 2005), are gaining in popularity. One reason for the popularity of engineering design competitions is the claim that they motivate students to learn and to work harder (Padget, 1997; Kaiser & Troxell, 2005; Wankat, 2005). However, there is a lack of research that describes this motivation (Chow & Law 2005), especially in any detail from the perspective and lived experience of the student.

**Purpose of the Study**

The purpose of this dissertation is to describe the life experience of motivation for competitors of International Robosub or Roboboat Competitions at a selective engineering university and to provide educators with a better understanding of how to use engineering competitions in a way that will motivate their students to learn. In order to accomplish this purpose, a phenomenological study, using in-depth interviews and document/artifact analysis, was conducted.

**Engineering International Competitions**

The specific engineering design competitions chosen for this study are the International Robosub Competition and the International Roboboat Competition. Both competitions are co-sponsored by the Association for Unmanned Vehicle Systems International (AUVSI) and the U.S. Office of Naval Research (ONR). The goal of the Robosub competition is to “advance the development of Autonomous Underwater Vehicles (AUVs) by challenging a new generation of engineers to perform realistic missions in an underwater environment” (Association for Unmanned Vehicle Systems International, 2011b,16th International RoboSub Competition, para. 4). In 2011, 26
university-based teams from six countries competed in this prestigious event. “The Roboboat Competition is a student robotics challenge in which teams race autonomous surface vehicles (ASVs) of their own design through an aquatic obstacle course” (Association for Unmanned Vehicle Systems International, 2011a, 6th International RoboBoat Competition, para. 1). In 2011, 15 university-based teams from three countries competed in the fourth annual event. Both events serve “to foster ties between young engineers and the organization’s developing . . . technologies” (Association for Unmanned Vehicle Systems International, 2011b, 16th International RoboSub Competition, para. 4).

**Grand Tour Research Question**

Creswell (2012) and McCaslin and Scott (2003) suggest that in a qualitative research process, such as a phenomenological study, there should be a grand tour question, which blends together “the primary colors of the problem statement and the purpose of the study in a harmonious composition. Typically, the grand tour question is written in the language of a tradition of inquiry (Creswell, 1998)” (as cited in McCaslin & Scott, 2003, p. 453).

The grand tour question that guided this study was: While preparing for and participating in International Robosub or Roboboat Competitions, what experiences—actual acts, specific behaviors, or other moments—bring about motivational responses for student contestants? To gain this information, the following sub-questions were explored:
1. How do student contestants describe their motivation and ascribe meaning to it personally?
2. In what context does motivation occur to them, individually and in interaction with others?
3. Who helped bring about motivation for these student contestants?
4. In what ways does this motivation propel them to act, learn, or achieve?

**Significance of the study**

The reason for studying educational motivation is fairly compelling when one considers the number of important factors that motivation influences: (a) task choices (Ryan & Deci, 2000); (b) persistence and confidence (Zimmerman & Ringle, 1981); (c) learning strategies (Veermans & Järvelä, 2004); and (d) achievement results (Pintrich & Schrauben, 1992), to name a few. Furthermore, “the importance of student motivation has varied from peripheral to central in psychological and educational research over the years. Currently, research on student motivation seems to be central to research in learning and teaching contexts” (Pintrich, 2003, p. 667). Studies have shown that students are more motivated to learn when comparing learning-centered learning to lecture-centered learning (Terenzini, Cabrera, Colbek, Parente, & Bjorklund, 2001) or faculty-centered learning as a whole (Blumberg, 2008).

The benefits of learner-centered education include increased motivation for learning and greater satisfaction with school; both of these outcomes lead to greater achievement (Johnson, 1991; Maxwell, 1998; Slavin, 1990). Research shows that personal involvement, intrinsic motivation, personal commitment, confidence in one’s abilities to succeed, and a perception of control over learning lead to more learning and higher achievement in school (Alexander & Murphy, 2000). (Blumberg, 2008, Section 3, number 3)
The importance of Blumberg’s points cannot be overstated. Satisfaction, motivation, achievement, and control over learning are goals of any education technique and through Blumberg’s research he has found that all of these benefits are achievable through learning-centered education.

Though some educators believe that it is enough to know that students are motivated by learning-centered education in order to justify the use of engineering design competitions, research suggests it is not enough. Instead educators must go beyond general motivation studies. Research can and should be improved by studying motivation from engineering design competitions directly. For instance, engineering design competitions fall within the learning-centered philosophy and are experiential, technology-based, collaborative, authentic, and project-based. In the article, “What Do You Mean by Collaborative Learning,” the author states:

Talking about the effect of such a broadly defined term would be as meaningless as talking about the benefit of taking a medicine, without specifying which one. One should not talk about the effects of collaborative learning in general, but more specifically about the effects of particular categories of interactions. (Dillenbourg, 1999 p. 12)

There are also dozens of motivational theories that might or might not explain the type and/or reason for engineering design competitor’s experience and feelings of motivation.

In addition to the significance derived from studying motivation, there are numerous statistics and stories that make compelling arguments for studying science, technology, engineering, and mechanics (STEM) based teaching techniques such as engineering design competitions. For instance, “The U.S. is ranked 27th (out of 29) for the rate of STEM bachelor’s degrees awarded in developed countries—6% of U.S. undergraduates major in engineering compared with 12% in Europe, 20% in Singapore,
and 40% in China” (Association for Unmanned Vehicle Systems International, 2011c, para. 3). In addition, according to the National Center for Education Statistics and the National Science Board, “Undergraduate programs in science and engineering report the lowest retention rates among all academic disciplines” (as cited in Association for Unmanned Vehicle Systems International, 2011c, para. 5). It also reports that less than half of undergraduates that plan to major in a STEM field complete a degree in one of those subjects (as cited in Association for Unmanned Vehicle Systems International, 2011c, para. 5).

Without studying the shared experience of these competitors, as it relates to motivation, we are leaving a significant engineering andragogical tool partially undiscovered and, therefore, not fully understood. This leaves the tool possibly underutilized. Through this dissertation, new knowledge will be added to the research and literature in the fields of learning, student motivation, and engineering design competitions.
CHAPTER 2

REVIEW OF THE LITERATURE

“The only source of knowledge is experience.” ~ Albert Einstein

It is my intention that the literature search provides educators with a better understanding of how to use engineering competitions in a way that will motivate their students to learn the design process. This literature search is consequently structured with that specific audience in mind, taking the form of both an informative survey of appropriate research-and also having the purpose of informing the audience of the relevant aspects of engineering design competitions.

While it is not possible to cover every theory that has been espoused over the last 100 plus years of motivation research nor every nuance of teaching methods, the next several sections of this work cover the classic and contemporary theories that make up the canon of motivational research and the learning approaches that are affiliated with engineering design competitions.

Since this dissertation is phenomenological in nature, I wanted to ensure that I balance the need to bracket any preconceived notions about the topic and the subjects with my need to understand my participants’ lived experience. In order to ensure this balance was achieved, I turned to Dilthey who stated:

To understand human experience, in addition to description of the experience as such, it was necessary to study history and that studies of experience are dependent on historical groundings and on descriptions in order to form a whole. (as cited in Moustakas, 1994, pp. 8-9)
Dilthey reminds researchers that it is necessary to have a background in the topic of the subject’s experience in order to code and analyze the meaning of the interviewee’s expressions.

The succeeding literature search follows Bruce’s (2001) concept of a subjective approach to scope, which is described as a psychological form of relevance where the author establishes a connection between the audience and the document.

**Motivation to Learn**

Motivation has numerous definitions. However, for this study, Mook’s definition will be utilized which states, “the study of motivation is the search for principles that will help us understand why people . . . initiate, choose, or persist in, specific actions in specific circumstances” (1987, p. 4). In this section of the literature search, the research is divided into three main sections the mechanistic period, the cognitive period, and current contemporary motivation constructs. It is important to note that most articles about motivation’s history (Graham & Weiner, 1996; Smelser & Baltes, 2001) begin with the 1930s and work their way to the present time. This tendency is likely due to the fact that most people who study motivation tend to be research psychologists, psychiatrists, educational psychologists, or some other form of behavioral scientist. Therefore, the historical articles on motivation tend to start about the time that empirical studies began to be accepted as a science. While I will not spend much time on these early philosophical theories, I do want to acknowledge the concepts.

From as far back as Plato’s time, there have been thoughts and theories about what motivates human beings to achieve learning. Ancient thought on motivation
centered on a concept known as hedonism. In this philosophical theory, people were motivated either to seek pleasure or to avoid pain. The problem with this ancient idea was that there was no way of defining or categorizing what was painful or pleasurable and no way to categorize either state for large groups of people because these concepts have vastly different meanings to every individual. However, philosophical thought, such as hedonism, and the idea of pleasure and pain did influence later theories (Crisp, 2006), especially in the Mechanistic Period.

**Mechanistic Period**

The decision to move toward more empirical research-based theories led to the first motivational historical period, which is characterized by psychologists and researchers who viewed humans as “machine like, without conscious awareness or volition and controlled by environmental forces” (Graham & Weiner, 1996, p. 65). This viewpoint earned the name, "Mechanistic Period," the timeframe in which theorists “portrayed the human as a machine-like reactive organism compelled to act by internal and/or external forces beyond our control (e.g., instincts, needs, drives, incentives, reinforcers, etc.)” (Smelser & Baltes, 2001, p. 10,110). Classic motivational theories that will be discussed in the following section include: behaviorism (Watson, 1913; Pavlov, 1928; Skinner, 1971), field theory (Lewin, 1951), and needs theories (Maslow, 1943; Herzberg, 1943).

**Behaviorism.** It was animal trials and the ideas of researchers such as Watson (1913), Pavlov (1928), and later Skinner (1971), which lead to the concepts of behaviorism. Watson, the founder of behaviorism, advanced the idea of animals’ response to punishment and rewards, a notion that he extended to human behavior:
The original program of behaviorism, as laid down by Watson, was very simple. It was to determine the relations between stimuli coming in from the environment and the response they evoke—so that, knowing the stimulus, we would know what response to expect, or knowing the response, we would be able to say what stimulus gave rise to it. (Mook, 2004, pp. 75-76)

Watson’s (1913) research hypothesized the following: if we knew which stimuli created a particular response, then we could use that stimulus to achieve the response we wanted to induce. For instance, if a professor knew that a failing grade would stimulate a student to learn more than a passing grade, then giving a failing grade, in theory, should evoke the response of studying.

At approximately the same time Watson was doing his studies, Pavlov (1928) was conducting his famous dog digestive studies. In this research, Pavlov found that dogs associated food with the people who were feeding them and would start to salivate whenever they saw someone wearing a lab coat. Pavlov then determined that he could recreate this salivation through a conditioned response. He formed an experiment where every time the dogs were about to eat, he would ring a bell. Eventually, the dogs equated the bell with food, and the sound of the bell would stimulate saliva manufacturing. From this study, classical conditioning was born.

Skinner (1971), perhaps the best known and possibly the most controversial of all behaviorists, set out to test the work of Watson and Pavlov through numerous experiments. One such experiment included rats in a box pressing a lever in an attempt to gain food or a reward:

Skinner discovered that the rate with which the rat pressed the bar depended not on any preceding stimulus (as Watson and Pavlov had insisted), but on what followed the bar presses. This was new indeed. Unlike the reflexes that Pavlov had studied, this kind of behavior operated on the environment and was controlled by its effects. Skinner named it operant behavior. The process of arranging the
contingencies of reinforcement responsible for producing this new kind of behavior he called operant conditioning. (Vargas, 2005, Graduate School and Discovery section)

Where Watson (1913) and Pavlov (1928) would suggest that giving a student a failing grade should stimulate them to study, Skinner argues that Watson and Pavlov had it backwards. Skinner believed that the student would operate according to their experience and would study in order to get a good grade or to avoid a failing grade.

These experiments, mostly with rats and pigeons, led Skinner to suggest that human beings are nothing more than an animal that operates and makes decisions based upon the concept of stimulus and response. With this suggestion, Skinner (1971) goes as far as to say that a human’s behavior is dictated by consequences of the behavior, either the reward or the punishment, and that human beings do not have “a free will, feelings, traits of character, purpose, or intentions” (Chomsky, 1971, p. 1). Skinner himself explains the concept of operant behavior:

It can best be explained with an example. A hungry rat is placed in a semi-soundproof box. For several days bits of food are occasionally delivered into a tray by an automatic dispenser. The rat soon goes to the tray immediately upon hearing the sound of the dispenser. A small horizontal section of a lever protruding from the wall has been resting in its lowest position, but it is now raised slightly so that when the rat touches it, it moves downward. In doing so it closes an electric circuit and operates the food dispenser. Immediately after eating the delivered food the rat begins to press the lever fairly rapidly. The behavior has been strengthened or reinforced by a single consequence. The rat was not ‘trying’ to do anything when it first touched the lever and it did not learn from ‘errors.’

To a hungry rat, food is a natural reinforcer, but the reinforcer in this example is the sound of the food dispenser, which was conditioned as a reinforcer when it was repeatedly followed by the delivery of food before the lever was pressed. In fact, the sound of that one operation of the dispenser would have had an observable effect even though no food was delivered on that occasion, but when food no longer follows pressing the lever, the rat eventually stops pressing. The behavior is said to have been extinguished (ca. 1978, para. 2-3).
To Skinner, operant conditioning is the sole reason that engineering design competitors are motivated to learn. He would suggest that upon hearing that there will be a test a student who is conditioned will begin studying. Any internal motivation to learn would likely be given the moniker of fiction, a description that he gave to any notion of free will.

In terms of how behaviorism might explain the motivation of engineering design competitors, the promise of a trophy, the adulation of peers, or some other nominal reward is a reinforcement, which can become a condition if the competitors are accustomed to winning. Equally possible might be that the student does not wish to disappoint teammates, and, therefore, the punishment of peer rejection could also be reinforcement.

Field Theory. During this same timeframe, a different concept of motivation was set forth by German psychologist and gestalt philosopher Kurt Lewin. Lewin (1951) saw behavior as a product of two forces: the individual and the individual’s situation. According to Mook (2004), when it came to motivation research, Lewin believed that there had not been enough emphasis placed on the importance of the situation in which individuals found themselves. “We are inclined (at least in this society) to emphasize the characteristics of the person—personality characteristics, personal preferences, and the like—and to downplay the importance of the situation. This may be a mistake (e.g. Nisbett & Ross, 1980)” (Mook, 2004, p. 321). Mook (2004) also pointed out that Lewin did not think that studying the situation alone was enough and believed that “what matters is the situation as the person perceives it” (p. 321). In order to understand how someone perceives their situation, Lewin created a vocabulary specific to his theory.
To start, Lewin turned to the concept of gestalt philosophy to define the whole. This wholeness is something that Lewin called the life space. Mook (2004) defined Lewin’s concept of life space as “the totality of things, goals, and persons that are affecting the person right now. The life space has parts—objects, other persons, and the like, but also memories of past events, and expectancies of events to come” (p. 322). Mook explains the concept using the example of an author writing a book. I will use Mook’s examples but instead anchor my examples in context of this dissertation. Within this dissertation, the life space will be the engineering design competition. Within the life space of an engineering design competition, there are objects such as the robosubs and roboboats that will be created, teammates and coaches representing the other persons within the life space, and past competitions and trials runs that represent the memories of past events within the life space. The expectation to win the competition is a clear representation of expectancies within the life space. Continuing with the engineering design competition metaphor: suppose a competitor is working steadily on the robosub’s guidance system, which is software coding that allows the robotic boat to autonomously steer itself through a predetermined path while avoiding obstacles. While working on the guidance system, the student then finds that he is under a time constraint to meet a deadline. In this scenario, Mook points out that the competitor’s life space would likely shrink down to just himself, the robosub, and the goal at hand. Mook also points out that anyone who tries to converse with this competitor while he is engrossed in his work, would likely get terse or incomplete answers. “There is little of his life space left over to deal with the conversation, if it is dominated by the goal of finishing the project” (Mook, 2004, p. 322).
Lewin also proposed the existence of positive and negative drives, or what Lewin called valences, where a positive valence was something that people were drawn towards action and a negative valence was something that people would avoid. For instance, the positive valence in the competitor’s experience might be to complete the guidance system. Valences are similar in nature to the positive and negative reinforcements of behaviorism.

Lewin next introduced the concept of tensions. Mook (2004) explains the concept of tensions as the differences between the current state and the ideal state. For instance, in terms of the engineering design competitor working on the software code for the autonomous guidance system, the fact that the competitor wants the guidance system finished, and it is not finished creates the sense of tension to complete the task. “Like a stretched rubber band, the difference between the present state and the desired state pulls the writer toward completion, the tension becomes stronger as nearness to the goal approaches” (Mook, 2004, p. 322). This tension explains that nagging feeling that people get when they are constantly reminded of the project that is not completed. Mook goes on to explain how the life space and the positive and negative valences can cause conflict. Consider the engineering design competitor who has the positive valence to design the roboboat’s guidance system but has the negative valence of self-doubt, questioning whether or not he has what it takes to get it done. These two opposing valences create conflict.

The final term that Lewin’s (1951) theory espouses is barriers. Mook (2004) explains that Lewin saw barriers within the life space, either physical barriers or psychological barriers. So, if the positive valence of completing the guidance system is
held up because of a lack of equipment, then the competitor is being held back by physical barriers. However, if the competitor gets burnt out due to being overworked and not feeling appreciated, the competitor then has experienced psychological barriers. Because this dissertation proposes to use a phenomenological methodology, Lewin’s language will likely provide useful terms for explaining the engineering design competitors’ motivation in terms of positive valences and tensions that are present in the design competitors’ life spaces.

**Needs Theories.** Throughout the 1940s, 1950s, and into the 1960s, a number of famous motivation theories offered a more humanistic alternative to the mechanical theories explained above. The earlier theorists believed that drives were what moved or motivated individuals. The next group of theorists believed that needs were the force that moved or motivated individuals. The subtle difference between needs and drives is that drives are considered innate and needs are “shaped, amplified, or suppressed through self-concept, social norms, and past experiences” (McShane & Von Glinow, 2009, p. 94).

The two need theories discussed within this section are Maslow’s (1943, 1954, 1970) needs hierarchy theory and Herzberg’s (1959) two factor theory (motivation and hygiene factors).

Maslow’s (1943, 1954, 1970) often tested theory, known colloquially as Maslow’s hierarchy of needs, helped to popularize the concepts of needs. Needs are “drive generated emotions that people have consciously or nonconsciously directed toward particular goals to correct deficiencies or imbalances” (McShane & Von Glinow, 2009). Maslow’s (1943, 1954, 1970) work is often classified in text books as a drive theory; however, a review of Maslow’s own words seems to show that he would have
taken exception with that categorization. In fact, in reviewing the 13 propositions in Maslow’s 1943 paper, it would seem that he had several disagreements with the idea that drives were biological. “Classifications of motivations must be based upon goals rather than upon instigating drives or motivated behavior” (Maslow, 1943, p. 371). Maslow also broke away from the conventional wisdom of the day which says that motivation theory and behavior research is too complex to be human-centered. “Motivation theory should be human-centered rather than animal-centered” (Maslow, 1943, p. 371).

Maslow’s 1943 work introduced what would eventually become his world famous hierarchy of needs. To produce his findings, Maslow (1943, 1954, 1970) combined numerous previously studied needs into five categories and then prioritized them into a hierarchy. “Human needs arrange themselves in hierarchies of pre-potency. That is to say, the appearance of one need usually rests on the prior satisfaction of another, more pre-potent need” (Maslow, 1943, p. 370). These pre-potent needs rank in order from most basic to most advanced. First were physiological needs, which Maslow states are the most pre-potent of all needs:

What this means specifically is, that in the human being who is missing everything in life in an extreme fashion, it is most likely that the major motivation would be the physiological needs rather than any others. A person who is lacking food, safety, love, and esteem would most probably hunger for food more strongly than for anything else. (1943, p. 373)

If the basic physiological needs are met, Maslow states:

other (and 'higher') needs emerge and these, rather than physiological hungers, dominate the organism. When these, in turn, are satisfied, again new (and still 'higher') needs emerge, and so on. This is what we mean by saying that the basic human needs are organized into a hierarchy of relative prepotency. (1943, p. 373)
These second higher order needs include safety, or the desire to feel safe in one’s environment, both physically and mentally. Third are social needs, including acceptance, friends, and relationships of many types. Fourth are esteem needs, which take social needs a step further and say that beyond belonging to a group, the individual wants to see that the relationship or belonging serves a higher purpose. In addition, esteem needs explain humans’ desire for praise and need for love. Finally, the highest echelon of needs, according to Maslow (1943), is the concept of self-actualization or creativity, understanding oneself, and personal exploration among others.

By the early to mid-1970s, most motivational experts agreed that Maslow’s work did not stand up to empirical scrutiny (Schneider & Alderfer, 1973; Wahba & Birdwell, 1973). Maslow himself was quoted as saying that he was surprised how widely his theory was accepted without any empirical research proving his observations. What is still important about Maslow’s work is that it established the concept of positive organizational behavior (Maslow, Stephens, & Heil, 1998), a belief that businesses should strive for a culture and environment that allows and assists employees to grow and utilize their strengths instead of focusing on their weaknesses. In addition, Maslow also provided an alternative to the concept that humans are nothing but a machine.

Another leading needs theorist and self-professed humanist, Frederick Herzberg, looked at needs and motivation from a work and philosophical perspective. Herzberg’s 1959 motivational-hygiene theory has had several updates over the years, but “the basics of the theory established in 1959 have remained firm” (Miner, 2005 p. 62). Herzberg’s study involved 203 engineers and accountants as subjects in a very large qualitative study. Herzberg utilized a semi-structured interview methodology providing his team of
13 assistants with a bank of preset questions but granted them the freedom of formulating unique and different questions inspired by the subject’s story. In the interviews, the subjects were asked to relay a story about a time at work when they could remember high or low events. These high and low events were then explored for feelings, attitudes, and effects, which included “job performance (based on the subject’s own reports of quantifiable or qualitative changes), mental health, interpersonal relationships, attitude toward the company, and other attitudes toward the working situation” (Adair, 2006, p. 71).

The results of the study were separated into first-level and second-level factors. The first level factors were a categorization of the event remembered. So, if a person shared that they felt a high event was being recognized by their boss, then it was categorized under possibility of growth. Then, the interviewer asked the question, “What did that event mean to you?” If the subject stated that the event meant they felt they could get a bigger bonus, then the secondary factor was categorized under salary. The 14 categories, including both the positive and negative stories, were: (a) recognition, (b) achievement, (c) possibility of growth, (d) advancement, (e) salary, (f) interpersonal relations, (g) supervision-technical, (h) responsibility, (i) company policy and administration, (j) working conditions, (k) work itself, (l) factors in personal life, (m) status, and (n) job security (Herzberg, 1959; Adair, 2006). The secondary factors, 11 in total, were similar to the 14 first-level such as “recognition, achievement, possible growth, responsibility, belonging and interest” (Adair, 2006, p. 71).

Finally, the research group analyzed the effects of the categories by utilizing the stories. If a low event included a poor supervisor, and the effect was that the person was
fired, then it would go under the effect of turnover. Adair (2006) described the five effects which included: (a) personal effects—“This major category included three subcategories. The first consisted of general comments about work being better or worse than usual; the second embraced comments about the rate of work; and in the third were mustered remarks concerning the quality of work” (pp. 75-76); (b) turnover—including termination, resignation, and on positive spectrum turning down offers to go to other work locations; (c) mental health—tension, weight loss and gain, smoking, drinking, disorders, anxiety, and stress; (d) interpersonal relationship effects—relationships with friends and family; and (e) additional effects—attitudes towards themselves, their colleagues, and the company itself.

Herzberg utilized the data he collected in his study to consider the needs of the subjects and surmised that there were two factors at play in his subjects. The first factor he labeled hygiene factors, and the second he labeled motivation factors. According to the theory, when the hygiene factors “supervision, interpersonal relations, physical working conditions, salary, company policies and administrative practices, benefits, and job security” (Crainer & Dearlove, 2004, p. 229) decline to a level that an employee would consider an unsatisfactory level, the employee becomes dissatisfied with his or her job. What the hygiene factors are not able to do, according to Herzberg’s theory, is to provide motivation. For the motivating factors, Herzberg turned to “achievement, personal development, job satisfaction and recognition” (Crainer & Dearlove, 2004, p. 229). Herzberg believed that these needs must be fulfilled in order for a person to be motivated by their job. While Herzberg’s two factor theory of motivation has had its
number of critics (Adair, 2006), he also still has a number of supporters (Bassett-Jones & Lloyd, 2005).

In 1966, Herzberg summarized his beliefs about needs and motivation, stating:

The human animal has two categories of needs. One set stems from his animal disposition, that side of him previously referred to as the Adam view of man; it is centered on the avoidance of loss of life, hunger, pain, sexual deprivation and in other primary drives, in addition to the infinite varieties of learned fears that become attached to these basic drives. The other segment of man’s nature according to the Abraham concept of the human being, is man’s compelling urge to realize his own potentiality by continuous psychological growth . . . These two characteristics must be constantly viewed as having separate biological, psychological and existential origins. (as cited in Miner, 2005 p. 62)

Herzberg’s (1966) concept of human beings wanting to achieve the needs of the basic drive and avoidance of fears, as well as their interest in autonomy makes Herzberg a bridge between the needs theories and the cognitive theories. It seems that his belief in achievement and fear is the precursor to achievement motivation theory of the cognitive period. Herzberg’s concept of autonomy later leads to a key point in contemporary self-determination theory.

Cognitive Period

In the last section, I discuss the early motivation theories which focused on innate drives, needs, or an outside environmental factor that moved humans to action. In this next section, I focus on the most influential theories of the cognitive era. These theories, unlike the earlier mechanistic theories, center on how conscious thought plays into people’s motivation. Said another way, cognitive motivation theories are built upon a person’s desires, expectations, and goals rather than some inherent, programmed, genetic reaction.
Achievement Motivation Theory. Atkinson’s (1957, 1964, 1966) theory promotes the idea of two purposes motivation: the first is the common idea of working toward achieving a goal, and the second is to avoid failing at a goal. Nicholls (1984) explained these two purposes are what are called achievement behaviors and defined them as “behavior in which the goal is to develop or demonstrate—to self and others—high ability, or to avoid demonstrating low ability” (p. 328). Shaffer (2009), explains if individuals are more motivated to succeed than they are motivated to avoid failure, they would be labeled ($M_s > M_{af}$). On the other hand, those people who are more motivated to avoid failure than to take the risk and aim for success would be labeled ($M_{af} > M_s$). Motivation then, according to Atkinson (1964), is directly affected by the level of avoidance of failure.

Atkinson’s theory (1957, 1964, 1966) posited that the motive to achieve a goal was based upon three determinants: (a) achievement motives, (b) expectancy for success, and (c) incentive values. McInerney and Van Etten (2004) point out that Atkinson defined expectancy for success as “individuals expended probability for success on a specific task, a value as the relative attractiveness of succeeding on a given achievement task, and also stated that incentive value is inversely related to the probability for success” (p. 167). In a similar fashion, there are three determinants of motivation to avoid failure: “the strength of one’s overall need to avoid failure, one’s estimate of the probability of failing the task, and the degree to which one fears the negative outcomes that such failure would bring (e.g. private disappointment, public embarrassment)” (Brophy, 2010, p. 45).
Attribution Theory. Another cognitive theory, which may be utilized for understanding an engineering design competitor’s meaning of motivation, is attribution theory (Heider, 1958; Rotter, 1966; Weiner, 1985, 1986). Attribution theory that is used today owes much to Weiner (1985, 1986), who realized the need for a new motivation theory when he became disenfranchised with the achievement theory proposed by Atkinson. In Weiner’s (2012) discussion on the theoretical development of the attribution theory, he talks about how, as a graduate student studying motivation, he was heavily influenced by his mentor Atkinson, the author of the achievement theory. In addition to working with Atkinson, Weiner (2012) speaks about being exposed to, and then summarily dismissing, the work of Heider (1958), citing it as being too philosophical and based in classic literature. He goes on to share that, while in school, he was influenced by the work of Newton and mathematicians, a clear sign of Atkinson’s influence.

Eventually, Weiner came to believe that there were significant problems with Atkinson using need for achievement as his construct for a motivation theory. At about that time, Rotter (1966) published an article on locus of control which inspired Weiner to reexamine Heider (1958). Weiner (2012) states that it was through the framework of Rotter’s article on locus of control that he was able to better see the value in Heider’s (1957) theory of ability, task difficulty, and effort. Mathematically, Heider’s original attribution theory was $Can \times Try$ which represented the belief that the more someone succeeds, the more motivated they are to try and do again. From Heider (1957) and Rotter (1966), Weiner (1985, 1968) was inspired to author the current attribution theory.
Before understanding the motivational aspect of the theory, it is vital to understand the term attribution. Harvey and Martinko (2011) describe attribution as “a causal explanation for an event or behavior” (p. 147). I will provide an explanation of attributional thinking using a faculty and student relationship. To explain, if a professor noticed a student falling asleep in class, the professor may try to determine an attributional explanation for the student’s behavior. Perhaps, the professor would assume that the student had been out partying all night, or the professor could assume that the student has been working double shifts to pay his tuition. Harvey and Martinko also suggest that people create attributional explanations for their own behavior. The same professor, seeing that 100% of her students have passed a test, could attribute the occurrence to her training in pedagogical techniques, or she could attribute the passing grades to her creating a test that was too easy. Attributions can fall under several dimensions. The two that are most relevant to this discussion include causality and stability. Harvey and Martinko describe causality as being either internal or external attributions. For instance, if a student fails a test and she attributes this failure to her own lack of studying, she can be said to be using an internal attribution. However, if she attributes failing the test to her roommate partying in the room, then she is using an external attribution. In addition, an attribution can also be considered either stable or instable. In the scenario of a student failing her test, if she decides that the reason she failed the test is because she has always hated tests, then she is said to be making a stable attribution. This would be stable because it is an attribution that will not likely change in the future. However, if she failed the test because she did not take the subject seriously and knows she can do better, then she is said to be making an unstable or less stable
attribute. It is then clear that the student realizes that she can do better in the future. Researchers use both of these dimensions at the same time so that in the example of the student who did not pass because her roommate was keeping her awake from partying, her attribution would be considered an external unstable situation.

Through studies of helplessness and depression (Abramson, Seligman, & Teasdale, 1978) and workplace aggression (Douglas & Martinko, 2001), research has been conducted regarding the common errors that people make when determining an attribution. Often these mistakes are made with such consistency that researchers have been able to label attribution styles. These error styles include optimistic attribution, pessimistic attribution, and hostile attribution. According to Abramson et al. (1978), a person who tends to attribute failure to an external attribute and a success to an internal attribute is said to have a “self-serving” optimistic attribution. Those who attribute failure internally and success externally are said to have pessimistic styles. Harvey and Martinko (2011) suggest that pessimistic attributors often attribute the internal failure to some stable reason. Abramson et al. also claim that pessimistic attributors often lack self-confidence and are cynical about their chance of success. The third style, hostile attribution, is similar to the optimistic attribution; however, when it comes to the external attribution being the cause of the failure, the individual likely has poor or hostile feelings toward the stable “entity” (i.e., a student that gets angry at his tutor for his bad grade).

In terms of motivation, researchers have identified four motivational states that can occur, two positive states, empowerment and resilience, and two negative states, learned helplessness and aggression (Harvey & Martinko, 2011). What is important to know about all four of the states is that they are derived from an individual’s past
experience and their interpretations or attributions about the future. Another way of saying this is “when people see that behaviors lead to desired rewards and outcomes, they are motivated to repeat those behaviors. When specific behaviors do not achieve desired outcomes, the motivation to perform those behaviors is lost” (Harvey & Martinko, 2011, p. 151). Following Harvey and Martinko’s line of thinking, individuals who repeatedly do not achieve their desired outcome will begin to attribute their failures internally and their successes externally.

Knowing that individuals tend to fall into this self-fulfilling prophecy of either repeated success or repeated failure and the attribution that goes with these outcomes, Harvey and Martinko (2011) share five ways that someone forming a team or hiring an employee can promote motivation. In terms of an educator or student leader forming an engineering design team, these motivation techniques could be essential toward promoting a competitor’s motivation. The techniques include: (a) screening for resilience in hiring and recruiting practices (Huey & Weisz, 1997); (b) partaking in attribute training so that the team or group has an understanding and an ability to adjust their erroneous attributions and become motivated to try (Martinko & Gardner, 1987); (c) immunization or setting new staff up for small scale success, thereby building up a positive script or attribution, before setting them off to tackle the more difficult projects (Martinko & Gardner, 1987); (d) utilizing two raters to evaluate performance (two raters help to correct for erroneous attributions of raters); and (e) practicing psychological closeness. Fedor and Rowland (1989) explain psychological closeness as motivational because supervisors or coaches who have done the same jobs or have recently worked in the same field tend to be less likely to place their own erroneous attributions on their
employees. Those supervisors who attribute failure in the team to team members demotivate the very members they are trying to motivate.

**Contemporary Constructs**

The last motivation period includes two current constructs that have emerged from cognitive motivation research during the 1980s and 1990s. These two concepts are intrinsic versus extrinsic motivation (Deci 1995), which then leads to the self-determination theory and task versus ego involvement (Nicholls, 1984). These two constructs are now the prime philosophies behind contemporary motivation theories.

**Intrinsic vs. Extrinsic Motivation.** One of the prevailing concepts in motivation today, though not universally accepted, is the idea that motivation is either intrinsic or extrinsic. Edward Deci, prolific researcher and author, relates the concept of intrinsic and extrinsic motivation in his 1995 book, *Why We Do What We Do*, by telling the story of three groups, a group of seals, a group of monkeys, and a group of children. Deci (1995) explains that at Brooklyn’s Prospect Park Zoo lives a group of seals who, in true behaviorist style, has learned to clap their hands, wave to the zoo patrons, and perform any other tricks that will get them fed by their keepers. Deci (1995) reiterates that as long as the reinforcement of food is present, the seals perform for the crowd exactly as expected. However, Deci also points out that as soon as the incentive or reinforcement is no longer present, or in this case the zoo keepers are no longer feeding them, so goes the motivation to perform the desired behavior. Regardless of whether or not the seals know how to perform for the crowd and whether or not the crowd wants the seals to wave, the lack of the reinforcement means there is a lack of performance.
Compare this to Deci’s next story of the internal motivation of rhesus monkeys.

According to Deci, Butler and Harlow (1954) took naturally curious creatures, rhesus monkeys, and put them one at a time into a cage with a mechanical puzzle and then observed the result. Deci explains that:

The monkeys took great interest in this mechanical puzzle. They would figure out how to open it, then how to close it up again. And they would repeat their actions many times. There were no tangible rewards for the behavior, and yet these naturally inquisitive monkeys were focused and determined. What’s more, they seemed to be enjoying themselves. Harlow used the term intrinsic motivation to explain why the monkeys had spent many hours working on the puzzles, where the only possible ‘reward’ seemed to be the activity itself. (Deci & Flaste, 1995, p. 18)

While Deci (1995) warns against relying too heavily on direct animal to human comparisons, he does suggest that human children often seem to learn like the monkeys. Deci (1995) suggests that young children have an infinite sense of curiosity and that they take delight in learning in all that they do. He suggests that they have a huge capacity for motivation to learn, not because of rewards, but because of what he perceives is the pure joy of learning. Deci goes on to share that as humans get older, the curiosity and motivation to learn seem to dissipate, and, as this happens, learning and motivation to learn wanes. To combat this, teachers tend to fall back into the carrot and stick model or treat-students like the trained seals.

Deci and his research partner Ryan have spent much of their ongoing careers studying the concepts explained above. What the two researchers have discovered is this: (a) external motivators can negatively affect internal motivation; (b) there are ways to inspire and create environments, which stimulate intrinsic self-motivation, sometimes with the correct external motivators and sometimes without any external motivators at all;
and (c) that all people can make decisions in an authentic and autonomous manner or in a controlled and inauthentic manner. To explain the last finding in terms of the subjects of this dissertation, if a person chooses to join an engineering design team for the thrill of the competition and because they would like to learn to design a robosub, Deci and Ryan (2008) would suggest that they are being authentic or living as their real-self and autonomous because they are making the choice themselves. On the other hand, a student who joins an engineering design competition because his best friend pressures him into participation is said to be controlled and inauthentic, meaning the competitor is not making decisions that are true to himself. He is not making the choice himself but instead is being forced, manipulated, or controlled.

**Self-Determination theory.** Deci and Ryan have conducted over 100 experiments into the three concepts above. As a result of this prolific work, Deci and Ryan produced the concept of self-determination theory (SDT), which is made up of one meta-theory and five sub-theories.

The overarching meta-theory states that humans have an innate desire to learn, grow, and develop. Deci and Ryan (1991) explained that:

> Human beings are oriented toward the active exercise of their capacities and interests. They seek out optimal challenges, and they attempt to master and integrate new experiences. In other words, they are engaged in a developmental process that is intrinsic to their nature and is characterized by the tendency toward a more elaborate and extensive organization. (pp. 238-239)

This concept is relayed in Deci’s (1995) earlier stories when he talks about the children’s innate interest in learning and playing. However, the meta-theory goes on to state that this interest in learning can be thwarted or nurtured depending on the social context of the individual. In terms of the social context or psychological needs that must be met, Deci
and Ryan (1985) argue there must be autonomy, competence, and relatedness present in the situation in order for internal motivation to be nurtured.

Beyond the meta-theory, five sub-theories emerged from Deci and Ryan’s collective work. To understand the first sub-theory, Deci (1971) provided college students a number of “intrinsically interesting puzzles” and asked the students to complete them. What was discovered was that performance is sometimes negatively affected by external rewards and that rewards do not always motivate performance. This finding became known as the cognitive evaluation theory (CET) or the theory that internal motivation is affected by external forces.

CET shows people feel “some tasks are inherently enjoyable, challenging, or significant. They do not merely feel obliged to complete these activities. When individuals feel intrinsic motivation, they tend to be more persistent. Burnout and exhaustion typically diminish” (Moss, 2012, Overview sec, para. 1). Moss goes on to explain that SDT demonstrates that if an individual completes a task in order to reap some reward or benefit, then the individuals are extrinsically motivated, which will lead to a decrease in their internal motivation.

Deci’s (1971,1975) CET was inspired by Vroom’s (1964) expectancy-value studies and numerous researchers have expanded upon the original work. Several of these spinoffs include examples of research that found external motivators that demotivate, including deadlines (Amabile, DeJong, & Lepper, 1976) and evaluations (Smith, 1975). Other researchers found external motivators, like task engagement (Gagne´& Deci, 2005), tend to increase internal motivation. According to Deci and Ryan (2012), there are two situations that will positively or negatively affect internal
motivation. First, if the external motivator causes a loss of control or the person to act in an inauthentic way, then the external motivator will cause a loss of internal motivation. If the external motivator does not threaten the subject’s sense of control or authenticity, then the internal motivation will not be negatively affected. Second, if the external motivator causes an increase in the subject’s confidence in completing the task, then the external motivator will either increase the internal motivation or will stay steady. However, if the external motivator decreases the subject’s confidence (negative feedback for instance), then internal motivation decreases.

A second sub-theory within the self-determination theory is the organismic integration theory (OIT). OIT builds off the original meta-theory that states that people have an innate desire to learn, grow, and develop. Within the findings of Deci and Ryan’s work, it was realized that the tendency or desire to learn must be adopted. This internalization or adoption can be enhanced or hindered by external motivators that have or lack autonomy and relatedness. Deci and Ryan (1985) suggest that the amount of autonomy and relatedness lead to a scale of adoption or internalization of the item that is being learned. The range of internalization goes from resistance on one end to adding the topic into your core personal beliefs on the other.

The third mini-theory, causality orientations theory (COT), describes individual differences in people’s behavior orientation and how people who embrace their own appropriate orientation will increase their motivation. “COT describes and assesses three types of causality orientations: the autonomy orientation in which persons act out of interest in and valuing of what is occurring; the control orientation in which the focus is on rewards, gains, and approval; and the impersonal or motivated orientation
characterized by anxiety concerning competence” (Self-Determination Theory. n.d., Formal Theory: SDT’s Five Mini-Theories sec., para. 6).

The fourth mini-theory is labeled basic psychological needs theory (BPNT) (Ryan, Williams, Patrick, & Deci, 2009). BPNT argues that there is a connection to psychological wellbeing and motivation. BPNT further states that autonomy, competence, and relatedness are basic psychological needs that are related to a person’s psychological health and wellbeing. BPNT then makes the connection that if any of the three needs are not present or are diluted, then the motivation will also be diluted.

The final mini-theory of SDT is goal contents theory (GCT). GCT relates to BPNT in that the theory builds off the claim that basic psychological needs must be fulfilled for wellness and wellbeing:

Whereas intrinsic aspirations are likely to satisfy the basic needs for autonomy, competence, and relatedness, extrinsic aspirations are likely to be unrelated to need satisfaction. These goal contents are theorized to have differential relations to basic needs, in part, because intrinsic goal pursuit may engender an inward orientation that is conducive to need satisfaction, whereas extrinsic goal pursuit may engender an outward orientation that is focused on garnering self-worth through achievement and external validation, detracting from basic need satisfaction (Vansteenkiste, Soenens, & Duriez, 2008). (Vansteenkiste, Niemiec & Soenens, 2010, p. 145)

Here, Vansteenkiste et al. (2010) make the argument that Deci and Ryan (1985) believe that intrinsic-based motivation and acts are more likely than extrinsic motivation to meet the needs of autonomy, competence, and relatedness. They also point out that the self-determination theory argues that extrinsic motivators can have a detrimental effect on intrinsic motivation’s efficacy. These concepts are carefully considered later in chapter five.
**Task vs. Ego Involvement.** The construct of task vs. ego involvement is an evolution to the earlier ideas of achievement motivational theory. The influence of Atkinson (1957, 1964, 1966) is especially obvious when you consider that the construct of task versus ego involvement essentially utilizes his achievement behavior definition. Nicholls (1984), perhaps the lead investigator into task vs. ego involvement, states, “Achievement behavior is defined as that behavior in which the goal is to develop or demonstrate—to self or to others—high ability, or to avoid demonstrating low ability” (p. 328). Nicholls (1984) hypothesizes that there are actually two forms of achievement goals and that they are based upon conceptions of abilities and types of goals. It is this separation of the two types of achievement that Nicholls adds to Atkinson and other achievement theorists’ works.

Nicholls (1984) suggests that the two types of achievements, which he labels “conceptions of achievement,” are both guided by an individual’s desire to achieve mastery. The first conception task involvement is intrinsic in that it relates to one’s professed mastery of knowledge, understanding, and attainment of information. Within task involvement, individuals judge themselves and are motivated to act based upon the desire to achieve a mastery of a subject or subjects. Also, the more difficult the knowledge that is to be obtained, the more likely someone is going to be motivated to try and obtain that knowledge.

The second conception takes a conflicting approach. Instead of relying on learning as a basis for achievement, Nicholls (1984) points out that ego involvement achievement is judged demonstratively and in comparison with a normative reference group. Ego involvement can then be defined as individuals who are motivated by
situations in which they are judged based upon their performance and effort, as might be seen in an engineering design competition.

**Summary**

As stated earlier, there are hundreds, if not thousands, of research studies about student and employee motivation. My decision to cover classic, and often no longer used, motivational theories alongside the contemporary constructs of today was intentional. All too often, in the research on motivation, the author spends countless column inches explaining why their research is better than others as well as much effort on convincing readers that the last well known theorist was wrong. However, from an outside perspective such as mine, I have concluded that many of the current day motivation theories are built upon the classic thoughts of the past. Would Skinner’s theory of operant conditioning be as understandable if he had not contemplated Pavlov’s thoughts on conditioned response? Would Herzberg’s hygiene-motivation theory have come about had he not studied the thoughts and debated the concepts of Maslow? Would Deci’s work be as rich without being able to debate the many theorists that came before him? Perhaps the answers to these questions are all yes, but I choose to believe that each of these theories is built in an iterative process, where one has built on the thoughts, concepts, and shortcomings of the theorist before. It is because of this belief that I included a progressive timeframe and have shown, when possible, how each theory connects with its “rivals.” I believe that understanding each of these classic and contemporary theories will allow me to be more fully informed in my subjects’ backgrounds and motivational experiences.

**Engineering Design Competitions**

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Overview

In addition to motivation theories, another key concept essential to this dissertation are engineering design competitions. At its core, an engineering design competition is a part of the engineering design curriculum. However, there are a number of ways that engineering design can be taught. If a professor is so inclined, he can teach engineering design utilizing the banking model of education (Freire, 1970) which utilizes a behaviorist approach of rewards and punishments in the form of quizzes and tests. In addition, a faculty member could utilize a more progressive flipped classroom approach (a process where students watch the lecture outside of the class and do the traditional assignments/homework in the class) (Miller, 2012). The students could also be taught through service learning which would require students to do hands on projects that are for the benefit of the community that a non-profit organization serves or that benefits society as a whole (Jacoby, 1996). These examples are just a few of the possible ways that individuals can be taught engineering design skills.

As reported earlier, this dissertation is studying the approach of utilizing an engineering design competition as a way of teaching engineering design skills. An engineering design competition falls under a number of categories or umbrella approaches. The remainder of the literature review overviews those educational approaches including the engineering design curriculum, experiential learning, and technology-based learning, which is comprised of collaborative learning, project-based learning, and authentic based learning.

Figure 1 provides a visual display of the educational approaches that are involved in an engineering design competition, including the three components of Kearsley and
Shneiderman’s (1998) engagement theory framework. This includes the following educational approaches: collaborative learning, project-based learning, and authentic learning.

Figure 1. Educational Approaches Utilized in an Engineering Design Competition

**Perceived Purpose of Learning**

While there is no widespread consensus as to the best way to teach and gain knowledge, there has been a strikingly steady, perceived purpose of education: to acquire and to share knowledge. Over the years, policy makers and opinion influencers have sought to add to that purpose. First Lady Eleanor Roosevelt (1930) pushed for
education’s purpose to include the act of creating citizens; Martin Luther King, Jr. (1947) called for an educational purpose that involved teaching individuals to think intensively, critically, and morally. Popular today is the notion that education should empower people to make a living and that education’s purpose is to operate as an economic engine (Hanushek, & Wößmann, 2007). No matter how the reader looks at these concepts, it does not negate that the perceived purpose of education has been to disseminate knowledge from one generation to the next. How this dissemination best takes place and if it should be disseminated or instead experienced with the purpose of creating new knowledge are both topics of a great debate that have been perplexing philosophers and educators for centuries.

One of the earliest recorded educators, Socrates, for whom the Socratic method of teaching is named, advanced a system of education where the teacher utilized systematic questioning, inductive reasoning, and universal definitions (Overholser, 1993) to cause students to dismantle their beliefs of what students think they know and rebuild new concepts and answers based upon these continued questions and discussions. This method of teaching led to other teacher-led interactions such as assigned recitations (Gates, 1922) where the pupil reviews written words and attempts to commit them to memory so that they can be recited back to the professor. Another approach was Antiphonal Catechism (Areeda, 1996) which was popularized in early religious education. The concept is that students are asked a battery of questions and rather than needing to figure out the answers, the “correct” answer is provided for them. Areeda provided the following example; the instructor asks a student "Who is God?" Rather than wait for the student to formulate an answer, an answer is provided: "God is the
maker of heaven and earth.” While debate might ensue or questions might come up, the answer that was provided is expected as a memorized answer the next time he or she is asked “Who is God?” Still other forms of faculty-led teaching methods have emerged over time.

Today the most popular of these methods is known as the lecture, and, as Bligh (1998) pointed out, whether you are talking about a classroom lecture, a political lecture called a speech, or a religious lecture called a sermon, the lecture is a “more or less continuous exposition by a speaker who wants the audience to learn something” (p. 4). Yet, Bligh goes on to point out that while lectures are as good as any other method of teaching in terms of transmitting information, they are not as good at encouraging discussion, promoting thought, changing attitudes, or teaching behavioral skills.

Bligh’s criticism of the lecture, the standard bearer of the faculty-centered learning philosophy, likely leads one to question if there is a better way to educate students. Perhaps there is pedagogy that would encourage discussion, promote thoughts, change attitudes, and teach behavior skills? The answer may very well be experiential learning.

Experiential learning is best described as “the change in an individual that results from reflection on a direct experience and results in new abstractions and applications” (Itin, 1999). Traces of the experiential learning philosophy can be seen as far back as Aristotle, who argued in his work *Nicomachean Ethics* that younger people could not possess the knowledge of politics because they had not lived the necessary experiences to understand the complexities of politics and government (Stein, 1995). Through this statement, Aristotle is pointing out that gaining knowledge through experience was the
only way for someone to truly understand the subject matter. Centuries later, American educator, philosopher, and father of the experiential learning movement, John Dewey (1938) would take Aristotle’s, Rousseau’s, and others’ beliefs and turn them into a theory that is still relevant today.

**Experiential Learning**

Every day we are confronted with experiences. Some we learn from others we allow to pass us by without acquiring new knowledge. Take, for instance, using a computer. Nearly everyone has had some experience using one, but, for the purpose of illustration, imagine an individual who has never touched a computer. It is possible for such an individual to gain a mastery of computers simply through traditional texts, lectures, and exams. Conversely, there are others who have a more self-taught mastery of computers. These individuals have never heard a professor or seen a PowerPoint on the subject. Next, there are those individuals who have the same experience with a computer as the self-taught master, and yet they never progress past the knowledge of a novice. Finally, there are those who have benefitted from having the traditional education and partaking in what is known as experiential education. These individuals are able to take advantage of prior knowledge gained from a textbook, a lecture, or a mentor, and to add it to the experience of utilizing a computer.

Intuitively this scenario makes sense, having both a formal education and a “hands on” opportunity makes for a richer education. What about the person who has had the opportunity to touch a computer and learns nothing from it, or the person who has the formal education and the opportunity to work with a computer, but still cannot achieve a level of demonstrative proficiency? This leads to a variety of questions: “Is
there more to experiential learning than just having an experience? Is there a better method of delivering learning outcomes than the traditional banking method?” (Freire, 1970). In short, this section will discuss the difference between having an experience and the concept of experiential learning (Dewey, 1938; Lewin, 1951; Piaget, 1952 & 1964; Kolb, 1984).

Experiential learning is a simplistic concept on the surface; it is the “sense making process of active engagement between the inner world of the person and the outer world of the environment” (Beard & Wilson, 2006, p. 2). Beard and Wilson (2006) go on to say:

The greatest strength of experiential learning is that it is an underpinning philosophy that acts as a thread joining many of the learning theories together in a more unified whole. Yet, the philosophy, while appearing relatively straightforward, is in actual fact rather complex and forces us to consider the nature of who we are and what we mean by experience. (pp. 16-17)

In spite of its perceived simplicity, Beard and Wilson (2006) point out that experiential learning is often inconsistently utilized and ineffective. They go on to point out that the main reasons why experiential learning can be ineffective are: (a) teachers, professors, and trainers do not understand the timing involved; (b) there is a general lack of awareness of how experiential learning can be utilized, and (c) there is a lack of knowledgeable people to serve as mentors, facilitators, and subject matter experts. In short, there is a lack of people to act as guides for the necessary reflection that must be present in order to learn. The next several subsections provide a context for what experiential learning is, how it was developed, and how it can be utilized.

**Experiential Learning According to Dewey.** Dewey’s seminal work on experiential learning provides criteria for what experiential learning should be, rather
than a definition of what it is. The first criterion of experiential learning is a social environment. Dewey (1938) states, "The principle that development of experience comes about through interaction means that education is essentially a social process" (p. 58). Dewey defines this social process as the individuals we come into contact with and the communication we use with those people. Dewey (1938) points out that, in order to learn from this social environment, there should be careful planning and care to nurture social relationships.

The responsibility of educating students goes beyond the teacher and involves the entire social system. The notion that it takes a village to raise a child is consistent with Dewey's experiential learning theory. Therefore, when discussing Dewey's philosophy of experiential education, the social environment within which education takes place is critical. (Roberts, 2003, p. 5)

In terms of this dissertation, the social relationships referred to by Dewey (1938) and Roberts (2003) could include peer-to-peer, professor-to-student, and competitor-to-coach.

The second criterion essential to Dewey’s (1938) theory is the nature of knowledge. Dewey rejected the notion that knowledge comes from the past and from the formally educated who decide for the novice what should be taught and what has value and importance. In this way, he disregarded the notion of teacher-centered education, calling instead for a nature of knowledge that comes from the life experiences of the students. “To imposition from above is opposed expression and cultivation of individuality; to external discipline is opposed free activity” (Dewey, 1938, p. 19).

According to Roberts (2003), a third criterion espoused by Dewey is the way that the curriculum content is organized. Roberts points out that Dewey finds separate subjects to be counter intuitive to learning, and he instead calls for learning to occur in an
environment that is as authentic as possible. Dewey (1938) suggests that this authenticity comes from a student learning while engaged in real-life situations.

Another vital criterion necessary for experiential learning is that students must be prepared to learn. This preparedness has several facets. According to Dewey (1938), it is essential to meet the students where they are, in terms of abilities. A faculty member can spend weeks putting together learning projects, but without the student having the ability, the knowledge, and frame of reference to gain knowledge and insight from these projects, the learning will occur sporadically, at best. A second facet of preparation is the student’s attitude, emotions, and situations. For instance, if a student arrives at the school preoccupied by a video game, emotionally distraught from a parent’s death, or even hungry, these distracters can play a significant role in preventing the student from being prepared to learn.

Dewey’s final essential criterion comes from his work *How We Think* and includes five essential steps of reflection. It is through reflection that Dewey (1933, 1938) sees experience becoming learning. Dewey (1933) suggested that the five phrases or aspects of reflective thought include:

(1) Suggestions, in which the mind leaps forward to a possible solution; (2) an intellectualization of the difficulty or perplexity that has been felt (directly experienced) into a problem to be solved, a question for which the answer must be sought; (3) the use of one suggestion after another as a leading idea, or hypothesis, to initiate and guide observation and other operations in collection of factual material; (4) the mental elaboration of the idea or supposition (reasoning, in the sense in which reasoning is a part, not the whole, of inference); and (5) testing the hypothesis by overt or imaginative action. (p. 107)

To illustrate how the five phases work in someone’s daily life, Dewey and Rater (1939) provided the following story:
Suppose you are walking where there is no regular path. As long as everything goes smoothly, you do not have to think about your walking; your already formed habit takes care of it. Suddenly you find a ditch in your way. You think you will jump it (supposition, plan); but to make sure you survey it with your eyes (observation) and you find that it is pretty wide and that the bank on the other side is slippery (facts, data). You then wonder if the ditch may not be narrower somewhere else (idea), and you look up and down the stream (observation) to see how matters stand (test of idea by observation). You do not find any good place and so are thrown back upon forming a new plan. As you are casting about, you discover a log (fact again). You ask yourself whether you could not haul that to the ditch and get it across the ditch to use as a bridge (idea again.) You judge that idea is worth trying, so you get the log and manage to put it in place and walk across (test and confirmation by overt action). (p. 105)

From this story, we can glean the ease and usefulness of Dewey’s (1939) five phases and the way in which they can be used as a demonstrative confirmation of what an individual has learned.

Many of Dewey’s followers have utilized these five phases of reflection along with the experience criteria and many of Dewey’s lectures and writings to create a number of experiential learning cycles that explain how these authors interpret Dewey’s contributions to experiential learning. The most famous cycle, which has come to be known as Dewey’s learning process, is shown in Figure 2. This cycle utilizes three of Dewey’s key terms—observation, knowledge, and judgment—to create an easily understandable plan for conducting experiential learning.
Another, and possibly more accurate, view of Dewey’s thoughts on experiential learning, is Kolb’s (1984) interpretation of Dewey’s writings. In Kolb’s model, he changes the concept of observation to include the term impulse to imply that there is both observation and immediate action. Kolb also changes the cycle from one with a clear starting point and ending point to a corkscrew model. This corkscrew style model, as depicted in Figure 3, represents a more continual and prolonged process. This model may have been inspired by the following quote of Dewey and Ratner (1939):

Inquiry is not like a race and the beginning of inquiry is not the line that is left behind at the top of the gun. With every step taken in the course of inquiry there is a new beginning issuing from a new ending; but beginning and ending do not follow upon each other—they intercept and unite. In walking along the right foot does not follow upon the left—both are working through the whole stride. What is an ending or a beginning depends upon the functional position as determined with the moment of inquiry. (pp. 212-213)
Lewinian Experiential Learning. Researcher Kurt Lewin, father of social psychology and creator of the field theory discussed earlier, appears as an experiential learning forerunner in nearly every study of experiential learning (Kolb, 1971; Kolb, 1984; Gentery, 1990; Beard & Wilson, 2006). To understand Lewin’s contributions, these and other sources suggest reviewing Lewin’s work on life spaces (1951) and active research/feedback process (1946). As stated earlier in this chapter, Lewin defines life spaces as the “field” or environment in which an individual experiences a topic. Kolb and Kolb (2005) point out that Lewin’s life space includes goals, unconscious stimuli, memories, and beliefs, along with political, economic, and social situations that lead to behavior (p. 199). In short, Lewin (1936) has argued that behavior is a function of the person and the environment in which they exist. He extends this argument to the behavior of learning to include the person interacting within his life space.

How an individual interacts and makes meaning of experiences within their life space is a topic of Lewin’s (1946) action research. Defined by Carr and Kemmis (1986)
as a form of self-reflection that individuals use to understand practices, situations, and behaviors within social situations, action research is the basis for Lewin’s version of an experiential learning cycle. Lewin’s cycle, known officially as the feedback cycle, has become his major contribution to experiential learning. Lewin (1946) describes the feedback cycle in the following words, which can also be seen in Figure 4:

The first step then is to examine the idea carefully in the light of the means available. Frequently more fact-finding about the situation is required. If this first period of planning is successful, two items emerge: namely, ‘an overall plan’ of how to reach the objective and secondly, a decision in regard to the first step of action. Usually this planning has also somewhat modified the original idea. (p. 205)


Piaget’s Theory of Cognitive Development. Piaget’s (1952) work in symbol-processing provided a number of vital elements that, when added to Dewey’s learning process and Lewin’s feedback model, make up most of the inspiration for Kolb’s (1984) current experiential learning theory.
Chief among Piaget’s (1952) contributions are what Kraft (1999) calls the four interrelated factors of mental development. These factors include: (a) physical maturation; (b) experiences that involve handling, moving, and thinking about concrete objects; (c) social interaction, particularly with other children; and (d) equilibration which results from bringing the other three factors together to build and rebuild mental structures (Kraft, 1999, p. 184).

Within Piaget’s cognitive development theory (1952) is an emphasis on concrete experiences, which he labeled as concrete phenomenalism. It was Piaget’s contention that children and adults learn better when they have a concrete experience which they can anchor to the knowledge. Kraft (1999) explained that “adolescents and adults, who are capable of formal abstract thought, need concrete experiences in order to develop new physical knowledge” (p. 184).

Kail and Cavanaugh (2007) described Piaget’s concept of concrete experiences in terms of children as naive physicists doing experiments with inanimate objects, such as blocks and toys. These child scientists are learning at a young age such lessons as gravity, inertia, and momentum even if they are simply playing with blocks and balls. Heider (1958) believed that adults were much like Piaget’s children scientists in that he considered most individuals to be naïve psychologists. Heider believed that individuals are often trying to make sense of other individual’s actions (see attribution motivation theory) by studying their behaviors, personalities, and other characteristics. To emphasize how well Piaget’s concept falls in line with experiential learning, I have amplified Dewey and Rater’s (1939) story example of how experiential learning works to demonstrate Piaget’s concrete experience and naïve scientist concept.
Within the Dewey and Rater (1939) story, one suddenly finds oneself facing a ditch, which initially one believes they will jump to cross. Dewey and Rater call this supposition and planning. Before the person jumps, they must survey the distance (observation according to Dewey and Rater) and find that it is a wider distance that the jumper believes he/she can achieve. Now, this person is a naïve mathematician using past experience to judge the distance, which can be jumped. They must also determine whether the bank on the other side is slippery; this is gathering fact and data, according to Dewey and Rater. According to Piaget (1952), the person is now a naïve hydrologist with concrete experience telling them that the mud is slippery. Eventually, as the story progresses, the person discovers a log and asks himself whether or not they could move the log to the ditch, get it across the ditch, and use the log as a bridge. This is another idea and plan, according to Dewey and Rater, and makes the person a naïve civil engineer, according to Piaget’s concept. The hypothetical person decides that the log is his best option, and so moves the log. The log is then put into place and used as a bridge to complete Dewey’s cycle with test and confirmation by overt action.

In addition to Piaget’s (1952) cognitive development theory, Piaget also seems to embrace Lewin’s concept of field theory (1951) and the basic Gestalt’s psychological concept that life is not made up of independent moments that are summed up to make a whole. Piaget (1964) explained:

For some psychologist development is reduced to a series of specific learned items, and development is thus the sum, the culmination of this series of specific items. I think this is an atomistic view which deforms the real state of things. In reality, development is the essential process and each element of learning occurs as a function of total development rather than being an element which explains development. (p. 176)
**Kolb’s Experiential Learning.** In 1984, David Kolb became the current day expert in experiential learning. Kolb (1984) did this by writing, what is perhaps, the most comprehensive text on the history of experiential learning. He refined his experiential learning theory (ELT) developed in 1971 and provided his own model for experiential learning as shown in Figure 5.

![Diagram](image)


In order to create the ELT, Kolb turned to the work of John Dewey, Kurt Lewin, Jean Piaget, William James, Carl Jung, Paulo Freire, and Carl Roger. From these pioneers’ work, Kolb identified six propositions, all of which he argues are shared by the aforementioned scholars (Kolb & Kolb, 2005). First, learning is best done as a process. “To improve learning in higher education, the primary focus should be on engaging students in a process that best enhances their learning - a process that includes feedback
on the effectiveness of their learning effort” (Kolb & Kolb, 2005, p. 194). Second, Kolb suggests that all learning is relearning, which he explains is derived from examining, challenging, and integrating new ideas. Third, Kolb argues that conflict and disagreements are necessary ingredients in the reflection phase of experiential learning. “In the process of learning one is called upon to move back and forth between opposing modes of reflection and action and feeling and thinking (Kolb & Kolb, 2005)” (Seel, 2012, p. 1216). Fourth, Kolb (1971, 1984) argues that experiential learning is a holistic approach that involves the individual’s senses, feelings, behavior, and perceptions. The fifth proposition, which Kolb (1971, 1984) espouses, states learning must be synergistic; people must be able to take what has been learned from one experience and utilize it later in other experiences; an individual must be able to take a lesson that was learned in one environment and translate it to a different environment. The final proposition in which Kolb (1971, 1984) uses as his basis for ELT is that experiential learning is based upon constructivist theory: each learner must make personal meaning with what they learn. He argues that traditional education simply asks one to transfer knowledge from the past and that ELT asks that individuals gain personal knowledge of the experience.

Included in ELT are four different abilities that Kolb (1984) argues are necessary in order to learn from experience:

Learners, if they are to be effective, need four different kinds of abilities- concrete experience abilities (CE), reflective observation abilities (RO), abstract conceptualizing abilities (AC) and active experimentation abilities (AE). That is they must be able to involve themselves fully, openly and without bias in new experiences (CE). They must be able to reflect on and observe their experiences from many perspectives (RO). They must be able to create concepts that integrate their observations into logically sound theories (AC) and they must be able to use these theories to make decisions and solve problems (AE). (p. 30)
Utilizing the ELT, Kolb provided what he argues is an improved experiential learning cycle (see Figure 5).

Beard and Wilson (2006) assert that Kolb’s (1984) experiential learning cycle has become so strongly established and so engrained in the experiential learning lexicon that it has almost become an “almost taken-for-granted theory of learning” (p. 40). That being said, there are still those who would challenge or criticize its message. One such critic, Miettinen (2000), brings up several concerns with Kolb’s theory. While the tone of Miettinen’s critique is less than cordial, his suggestions for improvement provide two important points that probably should be adopted into any comprehensive experiential learning theory. First, Miettinen argues that Kolb did not account for the human use of habit and maintains that habits are unconscious thoughts that do not bring about reflection. Second, Miettinen (2000) suggests that individuals utilizing Kolb’s (1984) cycle to learn are isolated in their reflection. It is Miettinen’s contention that experiential learning theory should utilize group reflection as a check and balance on poor hypotheses and conclusions that occur in Kolb’s (1984) stages.

Beard and Wilson (2006) also wrote about the same critiques. First, they provide a strong argument for why habits may be what Dewey called mis-educative or why we must at least be conscious of the limitations of learning that occur when we become creatures of habit.

Much of our lives are spent on automatic pilot, e.g. taking our normal route home after work and then realizing after we arrive we cannot remember anything other than the work problem we were contemplating. We just do not think, never mind reflect on many of the actions that we undertake. This is a natural process that prevents our conscious brains [from] becoming overwhelmed with all the things that we need to think about; however, it is not included in the learning cycle. (Beard & Wilson, 2006, p. 41)
Essentially, Beard and Wilson (2006) believe that habit is a form of behavior that does not lead to learning. They contend it takes little conscious thought or mindful reflection in order to accomplish the habitual actions.

Secondly, Beard and Wilson (2006) concur with Miettinen’s criticism that “the dangers of drawing wrong conclusions are less likely to occur when the individual interacts with others and the environment. . . provide[s] a ‘reality check’ on weaker concepts and hypotheses” (Miettinen, 2000, pp. 41-42).

**Summary**

Within the sections on experiential learning, I have reviewed the roots, definition, and criteria necessary for sound learning based in experience. The section also provides a background on the major contributions of Dewey (1938), Lewin (1936, 1946, 1951), Piaget (1952, 1964), and Kolb (1971, 1984) toward the present day understanding of experiential learning. Finally, this next section provides information on the foundational educational approach in which engineering design competitions are built.

**A Framework for Technology-Based Teaching and Learning**

In addition to the historical groundings of experiential learning, there are several other educational approaches that make up engineering design competitions. The framework, which assists in defining these other approaches, is found in Kearsley and Shneiderman’s (1998) work, *Engagement Theory: A Framework for Technology-Based Teaching and Learning*. According to Kearsley and Shneiderman (1998) the following three concepts must be present: (a) the learning must occur in a group context (i.e., collaborative teams), (b) it must be project-based, and (c) have an outside (authentic) focus.
Component 1: Group Context

This section of the literature search provides information into collaborative learning and the dynamics of collaborative groups or engineering design teams, the first of three key components necessary for technology-based learning (such as a robosub competition) to be effective. Topics discussed include: (a) an overview of collaborative learning; (b) a definition of a group or team (Shaw, 1981; Forsyth, 2010); (c) an understanding of the five stages of group development (Tuckman, 1965; Tuckman & Jensen, 1977); (d) the role of individuals on a team (Tucker, 1973; Johnson & Johnson, 1989); (e) group roles (Benne & Sheats 1948; Mudrack & Ferrell, 1995); and (f) team cohesiveness (Back, 1950).

Collaborative Learning. Collaborative learning is described as “an umbrella term for a variety of educational approaches involving joint intellectual effort by students, or students and teachers together” (Smith & MacGregor, 1992, p. 11). Educators that utilize collaborative learning techniques challenge their students to come to a solution for a problem, to discover knowledge, and often to create some practical end product (Smith & MacGregor, 1992). As an umbrella term, there are numerous types of collaborative learning activities, but chief among each of their characteristics is the exploration or application of the course material, not simply the teacher’s presentation or explication of it . . . . Collaborative learning represents a significant shift away from the typical teacher-centered or lecture-centered milieu in college classrooms. In collaborative classrooms, the lecturing/listening/note-taking process may not disappear entirely, but it lives alongside other processes that are based in students’ discussion and active work with the course material. Teachers who use collaborative learning approaches tend to think of themselves less as expert transmitters of knowledge to students, and more as expert designers of intellectual experiences for students-as coaches or mid-wives of a more emergent learning process. (Smith & MacGregor, 1992, p. 11)
The characteristics Smith and MacGregor (1992) espouse in the previous quote can be thought of as principles or guidelines for how teachers might utilize the students’ collaborative learning activities.

**Collaborative Learning is Experiential.** Smith and MacGregor (1992) share that collaborative learning is a constructive process which allows students to work in groups to integrate new material with concepts that the students already know.

To learn new information, ideas or skills, our students have to work actively with them in purposeful ways. They need to integrate this new material with what they already know—or use it to reorganize what they thought they knew. In collaborative learning situations, our students are not simply taking in new information or ideas. They are creating something new with the information and ideas. These acts of intellectual processing—of constructing meaning or creating something new—are crucial to learning. (Smith & MacGregor, 1992, pp. 11-12)

The previous statement expresses the authors’ belief that students who are utilizing collaborative learning, which also includes reflection, authentic experiences, and the amalgamation of new concepts into past learning, are gaining a higher level of learning than students who are simply taking in or memorizing information.

**Collaborative Learning Benefits.** Smith and MacGregor (1992) provide a long list of reasons that collaborative learning is a desirable educational approach; these reasons include the following:

In collaborative endeavors, students inevitably encounter difference, and must grapple with recognizing and working with it. Building the capacities for tolerating or resolving differences, for building agreement that honors all the voices in a group, for caring how others are doing—these abilities are crucial aspects of living in a community. Too often the development of these values and skills is relegated to the ‘Student Life’ side of the campus. Cultivation of teamwork, community building, and leadership skills are legitimate and valuable classroom goals, not just extracurricular ones. (p. 13)
The benefits that Smith and MacGregor (1992) share, which are likely to be found within an engineering design team, are diversity appreciation, enriched learning, involvement, leadership, and team work.

The following section is written to provide background, information, and research into group context and small group/team development.

**Defining Teams.** The concepts of collaborative teams are as complex and dynamic as the individuals that make up the group, perhaps more so when you layer in the dynamics of two or more unique individuals and the nearly infinite combinations of behaviors that can occur within teams. For the purpose of this study, the following definition of a team will be used throughout the study, “Teams are groups of two or more people who interact and influence each other, are mutually accountable for achieving common goals associated with organizational objectives, and perceive themselves as a social entity within an organization (Shaw, 1981)” (as cited in McShane & Von Glinow, 2009, p. 145).

**Team Development.** In order to conduct research into how engineering design teams develop or should develop, it is important to understand the dynamics, formation, activities, and struggles of a team or small group. Researchers have been studying group development since the early 1950s. The result has been a number of group development models (Bales & Strodtbeck, 1951; Lacoursiere, 1974; McGrath, 1991), but, as Wheelan and Hochberger point out, “Tuckman’s stage model has been a standard for many years and activities carried out during stages are recognized to be key components of group development” (as cited in Miller 2003, p. 122).
Tuckman (1965) synthesized 55 researchers’ work on small group development into a broad-based model of small group changes. Tuckman’s original research found that groups have four stages of development. Stage one, “forming”, requires that the group members establish their task and the manner in which the group members will acquire needed information. “Groups initially concern themselves with orientation accomplished primarily through testing. . . . Coincident with testing in the interpersonal realm is the establishment of dependency relationships with leaders, other group members, or preexisting standards” (Tuckman, 1965, p. 396). During the forming phase, the members test out their boundaries and establish their relationship with the group leaders and their fellow members.

The second stage, Tuckman called “storming”, within this phase “there are characteristic key issues that polarize the group and boil down to the conflict over progression into the unknown of interpersonal relations or regression to the security of earlier dependence” (Tuckman, 1965, p. 386). Key to this phase is that individuals are known to fight the group mentality to show a sense of individuality, in turn, causing a distinct lack of unity. Tuckman described this behavior in terms of fear of the unknown. He also found a secondary conflict that was present in this second stage of a group’s development. Here, Tuckman shared that group members displayed an “emotional reaction” to the group’s task. While specific emotions are not discussed, he did observe that the reaction was a defense mechanism or a “resistance to the demands of the task on the individual, that is the discrepancy between the individual’s personal orientation and that demanded by the task” (Tuckman, 1965, p. 386). A concrete example of Tuckman’s (1965) secondary conflict is the struggle that arises for a person when they find the group
work to be demeaning or boring. Rather than focus on the task at hand, the individual focuses on the way the work makes them feel. This lack of focus on the goals sets up the second form of storming.

Once past the volatile second phase, Tuckman found that groups enter into the third stage known as “norming.” Within the group, the resistance present in the earlier storming stage is replaced with a desire to see the group succeed and remain sustainable. “Harmony is of maximum importance, and task conflicts are avoided to insure harmony” (Tuckman, 1965, p. 386). During this third phase, groups develop common values and group norms to ensure group cohesion.

Tuckman labeled the fourth, and final, original stage as “performing.” In this phase, Tuckman postulated that groups were ready to achieve the goals that they originally set for themselves. “The group, which was established as an entity during the preceding phase, can now become a problem-solving instrument” (Tuckman, 1965, p. 387). As Tuckman (1965) points out, this is the only stage where the team is operating both efficiently and productively.

Twelve years after Tuckman’s (1965) original work into small group developmental sequencing, Tuckman and Jensen (1977) set out to review the research that explored Tuckman’s (1965) research—22 studies in all. Numerous research findings were summarized and discussed in Tuckman and Jensen’s work (Smith, 1966; Shambaugh & Kanter, 1969; Zurcher, 1969; Runkel, Lawrence, Oldfield, Rider, & Clark, 1971; Spitz & Sadock, 1973; Lacoursiere, 1974; Braaten, 1975).

The significant findings that came from Tuckman and Jensen’s (1977) work was they discovered a number of studies (Yalom, 1970; Spitz & Sadock, 1973; Braaten, 1975)
that included a termination stage and a number of authors that began to refer to the stages of development as a life cycle (Mills, 1964; Mann, 1971; Gibbard & Hartman, 1973). From these discoveries, Tuckman and Jensen (1977) reexamined the four-stage model and concluded that a termination stage was appropriate, stating:

Although Tuckman saw performing as the final stage of group evolution, those who agree with a life cycle model view separation as an important issue throughout the life of the group and as a separate and distinct final stage. With a substantial amount of activity taking place in training and therapy groups in which presumably strong interpersonal feelings are developed the ‘death of the group’ becomes an extremely important issue to many of the group members. As a reflection of the recent appearance of studies postulating a life cycle approach (Mann, 1971; Gibbard & Hartman, 1973; Spitz & Sadock, 1973; Lacoursiere, 1974; Braaten, 1975), the Tuckman model is hereby amended to include a fifth stage: adjourning. (pp. 425-426)

With this amendment to his work, the now five stages of small group development became more of a cycle than a list of guidelines. As a cycle, there is a definitive end to the small group development. Tuckman (as cited in Tuckman and Jensen, 1977) shares ways to make the adjournment effective for the productivity of the group.

While Tuckman’s amended model has become “the most predominantly referred to and most widely recognized in organizational literature” (Miller, 2003, p. 122), “not everyone agrees that there is a sequence of phases in the development of small groups” (Hare, 1994, p. 441). Critics fall into a number of camps, including those who do not believe there are any discernible phases of group development (Cissna, 1984; Gersick, 1988), those who believe that group development is an iterative process of continued growth (Barker, 1991), and those who believe that there are phases, but that there is not a life cycle. Those who believe there are phases but no-life cycle also believe that each
phase can be entered and completed numerous times, in any order, during the duration of the group’s existence (Hare & Naveh, 1978).

While it was important for me to consider these rival hypotheses, Tuckman’s model is still best for providing a common language (Bonebright, 2010) for those who are studying team and group subtleties. For the purpose of this dissertation, it will be as Rickards and Moger (2000) suggested, “a simple means of discussing and exploring team dynamics” (p. 277). Bonebright (2010) contends:

It is perhaps, unlikely that a model with similar impact will come out of the new literature . . . HRD scholars and practitioners can learn something from a model that has proved valuable for almost 45 years. The utility of providing a simple, accessible starting point for conversations about key issues of group dynamics has not diminished. (p. 119)

In addition, Tuckman's model has the advantage of being consistent with what students experience in team projects (Miller, 2003; McShane & Von Glinow, 2009) such as engineering design competitions.

**Team Design Elements.** Tuckman (1965) suggests that the formation stage requires team members to determine the task at hand, decide how they will gather information, and spend time testing the group. In order to understand how to appropriately form or design a team, a number of researchers have studied team design elements. Campion, Medsker, and Higgs (1993) and Campion, Papper, and Medsker (1996) provide a particularly useful framework for understanding the building blocks of group design or formation.

The first characteristic is job design which includes a team member’s ability to self-manage, participate in the group, perceive that their role has task variety, and determine the task is significant. The second characteristic is interdependence of the
task, the goals, and the feedback. McShane and Von Glinow (2009) write about the importance of this second characteristic, pointing out that:

One task characteristic that is particularly important for teams is task interdependence—the extent that team members must share materials, information, or expertise in order to perform their jobs (Van der Ve gt, Emans, & Vand de Vliert, 2001; Wageman, 2001; Gully et al., 2002; and Barrick et al. 2007). Task interdependence represents the collective degree of mutual dependence team members have on each other for resources. Pooled interdependence produces minimal interdependence, such as when team members share machinery, support staff, or some other resource from a common source. Interdependence is higher under sequential interdependence, in which the output of one person is the direct input for another person or unit (similar to relations among employees on an assembly line). Reciprocal interdependence, in which work output is exchanged back and forth among individuals, produces the highest degree of interdependence. (p. 150)

Without interdependence, as described by McShane and Von Glinow (2009), a group or team would just be a collection of individuals working in close proximity. Task interdependence makes the individuals into a group and an interdependent goal or goals begins to set the group up for success.

Campion et al.’s (1993) third characteristic is team composition, defined as heterogeneity, flexibility, and relative size. Regarding the importance of size, Campion et al. (1996) concluded:

Teams perceived as too large for their tasks were less effective than those whose size was perceived as being appropriate or too small for their tasks. However this result is consistent with the literature suggesting that larger teams may be detrimental to effectiveness (Sundstrom et al., 1990). It may be that coordination needs are already higher with professional jobs, so additional coordination requirements with larger teams create a burden. (p. 447)

The difficulty that surrounds the optimal size of the group is that it depends on the goals and purpose of the group. A group that is seeking feedback is able to grow slightly larger, whereas a group that has formed to make decisions should be smaller. A group
such as an engineering design team should function with only as many people as there are roles and perhaps an assistant or a backup person. As Campion et al. (1996) point out, having too many people can cause issues in the effectiveness of the group.

In terms of heterogeneity or team members’ perceptions that they are part of a group, Campion et al. (1996) found that groups with high retention rates and longevity of membership, and those who perceived themselves as an important part of the team were more effective. Campion et al. (1996) explain:

One important part of many definitions of teams is that the members should identify with and see themselves as a team . . . Teams with members that only belonged to one team, that had mostly permanent members, and especially that functioned as a team had more positive team characteristics and were often viewed as more effective. (p. 448)

If individuals do not see themselves as part of the team, they do not share in the interdependency of the group, and the experience can become akin to a missing piece of the puzzle. For a group to be highly effective and for the individuals involved to feel a sense of ownership, all contributors need to see themselves as active and important members of the team.

The fourth characteristic, labeled as context characteristics, includes training, managerial support, and communication between work groups. The fifth and final characteristic, known as process characteristics, includes communication within the group, social support, and morale.

In Campion et al.’s (1996) discussion, they gave the following advice from the results of their study, “Communication, workload sharing, and social support are all very important, but perhaps potency is most important. Enhancing potency (i.e., team self-efficacy or team spirit) highlights the value of coaching skills in the management of
teams” (Campion et al. 1996, p. 448). Said another way, a strong coach, supervisor, or leader can enhance the effectiveness and morale of a team if that person provides the appropriate support and feedback. While both context and process characteristics rated highly in both Campion studies, Hackman et al. (2000) point out that organizations are not very good at delivering these characteristics:

The structures and systems of many organizations have evolved over the years to provide good support for work that is performed by individual organization members. Work teams in such organizations may find it difficult or impossible to obtain the kinds of support they require, the special resources that teams need but that individual performers may not. (pp. 115-116)

Here Hackman et al. points out that most organizations are not sufficiently meeting the support needs of those who are working in teams.

What Hackman et al. (2000) suggest is that there are three features that should be present in order to take advantage of Campion et al.’s (1993) context and process characteristics. First, reward systems should be adjusted so that recognition is for the team as a whole, and there should not be a system in which individuals are recognized in ways that demotivate the rest of the team. Secondly, Hackman et al. (2000) suggest that team members should have access to technical or education training and development in any areas of knowledge, skills, and experiences that are necessary to perform the functions of the team. Third and finally, there should be support from other outside groups or individuals that provide the team with data, projections, and other related communication that would benefit the team in completing their goals.

**Team Process Elements.** Where team design is associated with the formation of an appropriate team, the concept of team processes are elements that assist the team in remaining sustainable and successful. Elements of team processes include individual
behavior (Johnson & Johnson, 1989), team roles (Benne & Sheats, 1948; Hare, 1994; Mudrack & Ferrell, 1995), team norms (Feldman, 1984), team cohesion (Beal, Cohen, Burke, & McLendon, 2003), and team trust (Robinson, 1996). While it might seem appropriate, even advisable, to discuss each phase of Tuckman (1965) and Tuckman and Jensen (1977) in terms of team process elements, the fact is that different aspects of the team process elements fit into each of Tuckman’s (1965) model. For instance, it is not possible to say that individual behavior is only an element of norming or only an element of performing. In fact, aspects of each of the team process elements are found in all five of Tuckman’s stages. For instance, individual behavior (Johnson & Johnson, 1989) and team roles (Benne & Sheats, 1948; Hare, 1994; Mudrack & Ferrell, 1995) have a role in explaining why storming takes place, how norming occurs, and what makes the performing stage effective. Therefore, rather than breaking the next sections down into storming, norming, performing, and adjourning, I have listed the team process elements and referred to their relations to different stages of Tuckman’s model as appropriate.

Individual Behavior. In terms of behavior, each member of the team has a number of possible ways in which they can act or interact with the other members and a number of roles that they can play within the group. To make sense of these possible individual behaviors, Johnson and Johnson (1989) postulate that there are three ways in which individuals comport oneself towards others: “One’s actions may promote the success of others, obstruct the success of others, or not have any effect on the success or failure of others” (p. 1). Johnson and Johnson (1989) label these three actions as promotive interaction (cooperation), oppositional interaction (competition), or no
interaction (individualistic efforts), and they suggest these behaviors together make up social interdependence, stating:

Social Interdependence exists when each individual’s outcomes are affected by the actions of others. Within any social situation, individuals may join together to achieve mutual goals, compete to see who is best, or act individualistically on their own. (p. 2)

In essence, Johnson and Johnson are saying that these three actions make up one of three ways in which an individual can interact or avoid interaction with their work group or team.

Social interdependence is a well-documented and well-researched subject with studies dating back to 1898. “Between that time and 1989, over 550 experimental and 100 correlational studies were conducted on social interdependence (see D. W. Johnson & R. Johnson, 1989, for a complete listing of these studies)” (Johnson & Johnson, 1996, p. 789). Johnson and Johnson (1996) report that there are three major areas of benefit to organizations based upon its members engaging in promotive interactions: achievement, positive interpersonal relationships, and psychological health. These will be discussed in the sections that follow.

Positive Interdependence and Achievement. The first benefit is based upon their ability to achieve their goals and outcomes, or what Tuckman (1965) would label, performing. Utilizing a meta-analysis of 375 studies of social interdependence and achievement, Johnson and Johnson (1989) found that those individuals that engaged in cooperative behavior were more likely not only to achieve or to perform but also to do so while displaying a:

1. Willingness to take on difficult tasks and persist, despite difficulties, in working toward goal accomplishment.
2. Long-term retention of what is learned.
3. Higher-level reasoning (critical thinking) and metacognitive thought. Cooperative efforts promote a greater use of higher-level reasoning strategies and critical thinking than do competitive or individualistic efforts (effect sizes = 0.93 and 0.97, respectively). Even on writing assignments, students working cooperatively show more higher-level thought.
4. Creative thinking (process gain). In cooperative groups, members more frequently generate new ideas, strategies, and solutions than they would think of on their own.
5. Transfer of learning from one situation to another (group to individual transfer). What individuals learn in a group today, they are able to do alone tomorrow.
6. Positive attitudes toward the tasks being completed (job satisfaction). Cooperative efforts result in more positive attitudes toward the tasks being completed and greater continuing motivation to complete them. The positive attitudes extend to the work experience and the organization as a whole.
7. Time on task. Cooperators spend more time on task than do competitors (effect size = 0.76) or students working individualistically (effect size = 1.17).

Johnson and Johnson’s (1989) list provides numerous examples and reasons that the authors advocate for cooperative learning, whenever possible.

In contrast, those groups that displayed an oppositional interaction, or that tended to discourage or to disrupt one another, were much less likely to achieve. Johnson and Johnson (1996) believe this oppositional interaction occurs as individuals “focus both on increasing their own success and on preventing anyone else from being more successful than they are” (p. 790). This oppositional interaction behavior could occur in any of Tuckman’s (1965) stages, but could be especially prevalent in the storming phase.

**Positive Interdependence and Interpersonal relationship.** The second group benefit derived from promotive interaction is a stronger interpersonal relationship with one’s work team. Again, Johnson and Johnson (1989) analyzed numerous studies and found that those group or team members who were engaged in promotive interaction behaviors tended “to care more about each other and to be more committed to each
other’s success and well-being . . . than when they compete to see who is best or work independently from each other” (p. 792). These positive feelings do not only manifest themselves in homogeneous groups. Johnson and Johnson (1989) found that these strong positive feelings are also present when groups and group members “differ in intellectual ability, handicapping conditions, ethnic membership, social class, culture, and gender. Individuals working cooperatively tend to value heterogeneity and diversity more than do individuals working competitively or individualistically” (Johnson & Johnson, 1996, p. 792). Johnson and Johnson (1996) believe some of the reason for this acceptance includes: (a) frequent and accurate communication that is not subjected to perception and assumptions, (b) more accurate perspective of other individuals, (c) flexibility and openness to be indoctrinated into a different mindset about people and their backgrounds, (d) personal feelings of acceptance among each person in the group, (e) lack of attacks to the self-esteem, and (f) expectations of future success due to interaction with individuals in the group.

In addition to an increase in friendly feelings toward one’s teammates, Johnson and Johnson (1996) also found that student “cooperators give and receive considerable social support, both personally and academically” (p. 792). They also found that the teammates were supportive in ways that promoted: (a) productivity, (b) physical health, and (c) coping with stress and adversity (Johnson & Johnson, 1996, p. 792). Again, interpersonal relationships are an aspect of nearly every stage of Tuckman’s (1965) model but are essential in the norming and performing stages where people are creating the unspoken rules of the group, or when individuals are delivering on the goals of the organization.
**Positive Interdependence and Psychological Health.** Finally, Johnson and Johnson (1989) found one last major correlation for those individuals that engaged in promotive interaction. Unlike the first two findings, which were benefits to the group, the final correlation seems to be more of a realization about members who are engaged in cooperation versus those that insist on being competitive or individualistic. I chose to include this finding as it may assist me in understanding some of my interview subjects. It may also assist educators, administrators, or even team leaders who are reviewing individuals for potential positions on a team. In 1989, Johnson and Johnson reviewed numerous studies on social interdependence and psychological health, they found that:

Cooperativeness is positively related to a number of indexes of psychological health, such as emotional maturity, well-adjusted social relations, strong personal identity, ability to cope with adversity, social competencies, and basic trust in and optimism about people. Personal ego-strength, self-confidence, independence, and autonomy are all promoted by being involved in cooperative efforts. (as cited in Johnson & Johnson, 1996, p. 792)

The strengths that Johnson and Johnson (1996) share in the previous quote are skills which are highly sought after in members of small groups. It stands to reason that an engineering design team leader or advisor should look for cooperativeness in any potential new member of the team.

Conversely, those people who displayed an inability to cooperate and tended toward individualistic behaviors were found to display characteristics of “emotional immaturity, social maladjustment, delinquency, self-alienation, and self-rejection” (Johnson & Johnson, 1996, p. 792). Those who tended toward competitiveness were found to have a mixture of some of the positives and negatives of each of the other two behaviors (1996, p. 792).
**Promotive interaction.** Numerous researchers (Kohn, 1986; Johnson & Johnson, 1989) claim that competition is far inferior to collaboration when it comes to learning. This might lead someone to wonder why this dissertation would set out to inform and encourage the use of engineering design competitions. It is important to understand that competition is not the main pedagogy that faculty are using to teach engineering design. There are plenty of opportunities to learn from the competition experience and their competitors, but the vast majority of the engineering design learning takes place months before the competition. Rather, the learning generally takes place in a cooperative or collaborative environment. Furthermore, Johnson and Johnson (1989, 1996) do not criticize a spirit of competitiveness, as will be seen in the International Robosub and Roboboot competitions. Instead, it is a critique of the earlier explained oppositional interaction.

To assess whether an engineering design competition is in-line with the positive interdependence that Johnson and Johnson (1989) espouses, a review of promotive interaction is in order and is outlined below. They state:

Positive interdependence creates promotive interaction. Promotive interaction occurs as individuals encourage and facilitate each other’s efforts to reach the group’s goals (such as maximizing each member’s learning). Group members promote each other’s success by (D. W. Johnson & R. Johnson, 1989):

1. Giving and receiving help and assistance. In cooperative groups, members both give and receive work related and personal help and support. Hooper (1992a) found a positive and significant correlation between achievement and helping behaviors.

2. Exchanging resources and information. Group members seek information and other resources from each other, comprehend information accurately and without bias, and make optimal use of the information provided (e.g., Cosden & English, 1987; Hawkins et al., 1982; Webb, Ender, & Lewis, 1986). There are a number of beneficial results from (a) orally explaining, elaborating, and summarizing information and (b) teaching one’s
knowledge to others. Yueh and Alessi (1988) found that a combination of group and individual rewards resulted in increased peer teaching. Explaining and teaching increase the degree to which group members cognitively process and organize information, engage in higher-level reasoning, attain insights, and become personally committed to achieving. Listening critically to the explanations of group mates provides the opportunity to utilize other’s resources.

3. Giving and receiving feedback on taskwork and teamwork behaviors. In cooperative groups, members monitor each other’s efforts, give immediate feedback on performance, and, when needed, give each other help and assistance. Carrier and Sales (1987) found that students working in pairs chose elaborative feedback more frequently than did those working alone.


5. Advocating increased efforts to achieve. Encouraging others to achieve increases one’s own commitment to do so.

6. Mutually influencing each other’s reasoning and behavior. Group members actively seek to influence and be influenced by each other. If a member has a better way to complete the task, group mates usually quickly adopt it.

7. Engaging in the interpersonal and small group skills needed for effective teamwork.

8. Processing how effectively group members are working together and how the group’s effectiveness can be continuously improved. (Johnson & Johnson, 1996, p. 790)

Johnson and Johnson’s (1996) list above does not necessarily establish whether an engineering design team utilizes positive or negative interdependence, but it does set up a guideline from which an observer can judge if positive interdependence is present.

**Hindering Factors.** Engineering design teams can also be involved in negative interdependence as stated by Johnson and Johnson (1996):
Many groups are ineffective and some are even destructive. Almost everyone has been part of a group that has wasted time and produced poor work. Ineffective and destructive groups are characterized by a number of dynamics (D. W. Johnson & F. Johnson) such as social loafing, free riding, group immaturity, uncritical and quick acceptance of members’ dominant response, and groupthink. (p. 793)

According to Johnson and Johnson (1996), engineering design teams must be watchful for social loafing, free riding, group immaturity, uncritical and quick acceptance of members’ dominant response, and groupthink. Each of these warning signs are discussed through the remainder of this section.

Johnson and Johnson’s (1996) observation should not be confused with Tuckman’s storming phase. While it is true that many, if not all, of these hindering factors could be found in the storming phase, many of them can be found in or as a result of individual choices in the performing or even norming phases. Regardless of which phase these six hindering factors (Johnson & Johnson, 1996) are found, they are clearly impediments to an engineering competitor being motivated. Therefore, it is important to review literature and standard definitions relating to each. It is also essential that I am conscious of these factors during the interviews and during the interpretation of the data derived from the interviews.

The first hindering factor, social loafing, “occurs when people exert less effort (and usually perform at a lower level) when working in teams than when working alone (Karau & Williams, 1993; Linden et al., 2004; Chidambaram, 2005; Klehe & Anderson, 2007)” (McShane & Von Glinow, 2009 p. 148). Similarly, free riding “refers to a member of a group who obtains benefits from group membership but does not bear a proportional share of the costs of providing the benefits” (Albanese & Van Fleet, 1985, p.
Group immaturity can be seen when organizations have not yet or never enter the performing stage of Tuckman and Jensen’s (1977) stages of development. Another form of group immaturity can be seen when group roles are not well defined or established, leading to a dependency on the group leader (Bradford, 1950). Uncritical and quick acceptance of members can result in a number of hindrances such as a lack of understanding of the prime goals of the group or a lack of normative integration (Thibaut & Kelley, 1959; Feldman, 1973). This lack of normative integration, in terms of Tuckman’s model, would mean that the new members are unable to integrate with the norms that the small group members established in the norming phase, which in turn could cause a small, performing group to return to the storming phase because of the introduction of the new member.

Dominant response is the tendency for people to perform the most obvious action. Research has found that when the task is simple, the dominant response is often correct. However, when the task is difficult or unfamiliar, the dominant response is often incorrect (Zajonc, 1965; Cottrell, Wack, Sekerak, & Rittle, 1968). To make things more complicated, both Zajonc (1965) and Cottrell et al. (1968) found that the dominant response is utilized even more heavily in the presence of others such as team members.

Johnson and Johnson’s (1996) final hindering factor example is actually multiple breakdowns of group decision-making, which Janis (1972) coined as groupthink. In reality, groupthink includes collective avoidance and collective over-optimism which Esser (1998) describes as a group or group leader’s “defensive reaction to potential failure” (p. 135). Instead of recognizing potential failure, the group ignores even the possibility that the failure could occur. Janis (1972) described groupthink as occurring
when groups felt pressure to succeed or to deliver a desired result so much so that there was a corrosion of “mental efficiency, reality testing, and moral judgment” (p. 9).

Johnson and Johnson (1996) not only warned of these six hindering factors, but also shared an idea of how to eliminate them stating, “Such hindering factors are eliminated by carefully structuring the five essential elements of cooperation. Those elements are positive interdependence, individual and group accountability, promotive interaction, appropriate use of social skills, and group processing” (p. 793).

**Team Roles.** A number of researchers point out that there are two categories of team roles. First, formal roles, those acquired by election, appointment, or self-selection “with rights and duties toward one or more other group members” (Hare, 1994, p. 434). The second role category, informal roles, is a function of the choices, personality, and behavior of the members within the group (Benne & Sheats, 1948; Mudrack & Ferrell, 1995). Both types of team roles likely are involved in the development of motivation. Those students who take on responsibility may find that they feel motivated based upon the recognition as a leader by their peers (Maslow, 1943; Amabile, 1993; Hars & Oh, 2001; Roberts, 2005). The stress and raised expectation of being responsible may propel the student to become more motivated and successful (Marks, 1977; Day, Sin, & Chen, 2004). The sheer fact that they are able to determine the direction and decisions of the group or exert authority may influence the individual’s motivation (Herzberg, Mausner, & Snyderman, 1959; Fehr, Herz, & Wilkening, 2012). Research into both business teams and team sports suggests that informal leaders and group members are motivated when they trust and believe in the vision or direction of the formal peer leader or coach (LaFasto, & Larsson, 2001; Vazou, Ntoumanis, & Duda, 2005, 2006). Inversely, their
motivation can be negatively influenced when they do not believe in their coach or peer leader’s vision or direction.

The second category of team role, informal functional role, may likely have an equal or greater influence on an engineering design competitor’s motivation. For example, in terms of sports, one may see that a team member that is not the captain or the star player is still valuable in his role as an “energizer,” in the sense that he is able to urge his teammates on to higher and greater achievements. In the classroom, a student who shows the characteristics of a “dominator,” someone who constantly interrupts others with her own opinions, can influence the classroom as much or more as the teacher.

Mudrack and Ferrell (1995), quoting the work of Benne and Sheats (1948), identified three categories of these informal functional roles within small groups and teams. The categories included: (a) task roles, (b) building and maintenance roles, and (c) individual roles. Within each category are a number of role titles. The task category includes 12 distinct roles, seven building and maintenance roles, and eight individual roles. Identifying and understanding the type of roles that each of the dissertation subjects hold within the engineering design team will allow for a fuller picture of what might influence their experience of motivation. It will also show how they influence the motivation of their teammates. Further, researchers might also find ways to measure the differences in motivation for each of Benne and Sheats’ (1948) role types. A listing and short description of the roles are included in Mudrack and Ferrell’s (1995) table below:
Table 1

*Functional Roles of Small Group Participants*

<table>
<thead>
<tr>
<th>Roles</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Task Coordinator</td>
<td>Pulls together related ideas or suggestions; clarifies the relationships between various ideas or suggestions; tries to coordinate the activities of various members or subgroups.</td>
</tr>
<tr>
<td>Elaborator</td>
<td>Expands on suggestions; offers a rationale for suggestions previously made; tries to figure out how an idea or suggestion would work out if adopted by the group.</td>
</tr>
<tr>
<td>Energizer</td>
<td>Tries to prod the group to action or decision; attempts to stimulate or arouse the group to greater or higher quality activity.</td>
</tr>
<tr>
<td>Evaluator-critic</td>
<td>Gives a critical analysis of a suggestion or idea; evaluates or questions the practicality, logic, or facts of a suggestion; holds the group up to a standard of accomplishment.</td>
</tr>
<tr>
<td>Information giver</td>
<td>Offers facts or opinions; relates one's own experience directly to the group task or problem.</td>
</tr>
<tr>
<td>Information seeker</td>
<td>Asks for facts, opinions, or interpretations; seeks clarification of suggestions made.</td>
</tr>
<tr>
<td>Initiator-contributor</td>
<td>Proposes tasks, goals, or actions; suggests solutions, procedures, or ways of handling difficulties; helps to organize the group.</td>
</tr>
<tr>
<td>Opinion giver</td>
<td>States beliefs or opinions pertinent to a suggestion made or to alternative suggestions; emphasizes what should become the group's view of pertinent values, not primarily relevant facts or information (combined with information giver role).</td>
</tr>
<tr>
<td>Opinion seeker</td>
<td>Asks not primarily for the facts of the case but for a clarification of the values pertinent to what the group is undertaking or of values involved in a suggestion made or in alternative suggestions (combined with information seeker role).</td>
</tr>
<tr>
<td>Roles</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Orienter-clarifier</td>
<td>Defines the position of a group with respect to its goals by summarizing what has occurred; points to departures from agreed on directions or goals; raises questions about the direction that the group discussion is taking.</td>
</tr>
<tr>
<td>Procedural Technician</td>
<td>Does things for the group; performs routine tasks such as distributing materials, taking notes, typing, photocopying.</td>
</tr>
<tr>
<td>Recorder</td>
<td>Writes down suggestions, makes a record of group decisions, or writes down the product of discussion; provides group memory (combined with procedural technician role).</td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
</tr>
<tr>
<td>Compromiser</td>
<td>When one's own idea or position is involved in a conflict, tries to offer a compromise (for example, by yielding status, admitting error, maintaining harmony, or meeting the group halfway).</td>
</tr>
<tr>
<td>Encourager</td>
<td>Praises, agrees with, and accepts the contributions of others; friendly, warm, and responsive to others; offers commendation and praise, and acceptance of other points of view, ideas, and suggestions.</td>
</tr>
<tr>
<td>Follower</td>
<td>Passively goes along with the ideas of others; serves as an audience in group discussion and decision.</td>
</tr>
<tr>
<td>Gatekeeper and Expediter</td>
<td>Attempts to keep communication channels open; encourages the participation of others; tries to make sure that all group members have the chance to participate.</td>
</tr>
<tr>
<td>Harmonizer</td>
<td>Attempts to reconcile disagreements among group members; reduces tension; gets people to explore differences.</td>
</tr>
<tr>
<td>Observer and commentator</td>
<td>Comments on and interprets the group's internal process.</td>
</tr>
<tr>
<td>Standard-setting/ego-ideal</td>
<td>Expresses standards for the group to attempt to achieve in its functioning or applies standards in evaluating the quality of group processes (combined with evaluator-critic role, as both involve standards of achievement).</td>
</tr>
<tr>
<td>Roles</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Individual</td>
<td></td>
</tr>
<tr>
<td>Aggressor</td>
<td>Expresses disapproval of the acts, values, or feelings of others; attacks the group or the group's problem; shows envy toward another's contribution or tries to take credit for it; jokes aggressively.</td>
</tr>
<tr>
<td>Blocker</td>
<td>Tends to be negative; resists the direction the group is headed in; tends to disagree and oppose beyond reason; attempts to bring back an issue the group has bypassed or rejected.</td>
</tr>
<tr>
<td>Dominator</td>
<td>Tries to assert authority or superiority and to manipulate the group or certain members of the group (for example, through flattery, giving directions authoritatively, or interrupting the contributions of others).</td>
</tr>
<tr>
<td>Evader and self-confessor</td>
<td>Uses the audience that the group setting provides to express personal interests, feelings, or opinions that are unrelated to the group's purpose; stays off the subject to avoid commitment.</td>
</tr>
<tr>
<td>Help-seeker</td>
<td>Attempts to call forth sympathy responses from other group members by expressing insecurity, personal confusion, or self-deprecation.</td>
</tr>
<tr>
<td>Playboy/girl</td>
<td>Makes a display of one's lack of involvement in the group's processes (for example, through cynicism, nonchalance, horseplay, and other more or less studied forms of out-of-field behavior).</td>
</tr>
<tr>
<td>Recognition seeker</td>
<td>Works in various ways to call attention to oneself (for example, through boasting, referring to personal achievements, or acting in unusual or inappropriate ways).</td>
</tr>
<tr>
<td>Special-interest pleader</td>
<td>Speaks for the small business person, the grass-roots community, the housewife, labor, and so forth, usually cloaking any prejudices or biases in the stereotype that best fits one's own individual needs.</td>
</tr>
</tbody>
</table>

The Process of Norming. Closely related to the informal functional roles of a team or small group are the acceptable and unacceptable team norms. “Group norms are the informal rules that groups adopt to regulate and regularize group members’ behavior. Although these norms are infrequently written down or openly discussed, they often have a powerful, and consistent, influence on group members’ behavior (Hackman, 1976)” (as cited in Feldman, 1984, p. 47). Team norms, for instance, might be utilized to prevent a member prone to being an aggressor from using aggressive jokes. McShane and Von Glinow (2009) describe norms in the following way:

Norms are enforced in various ways. Co-workers grimace if we are late for a meeting or make sarcastic comments if we don’t have our part of the project complete on time. Norms are also directly reinforced through praise from high-status members, more access to valued resources, or other rewards available to the team. But team members often conform to prevailing norms without direct reinforcement or punishment because they identify with the group and want to align their behavior with the team’s values (p. 154).

Norms can also have a corrective action. For instance, a member who is constantly texting during team meetings can quickly see that his teammates do not accept his lack of attention.

Feldman’s (1984) study provides a clear connection between the importance of team norms and how they influence group satisfaction. This, in turn, is another potential influencer of motivation. Feldman explains in the following quote:

In addition, groups want to ensure the satisfaction of their members and prevent as much interpersonal discomfort as possible. Thus, groups also will enforce norms that help the group avoid embarrassing interpersonal problems. Certain topics of conversation might be sanctioned, and certain types of social interaction might be openly discouraged. Moreover, norms serve an expressive function for groups (Katz & Kahn, 1978). Enforcing group norms gives group members a chance to express what their central values are, and to clarify what is distinctive about the group and central to its identity (Hackman, 1976). (Feldman, 1984, p. 48).
Feldman’s (1984) quote points out that norms play an essential role in an individual feeling comfortable and feeling as if they are an equal and a valuable member of the group.

**Team Cohesion.** Two final team process elements that are essential for the sustainability and effectiveness of teams are the concepts of team cohesiveness and team trust. As one might imagine, both of these concepts are essential in group development in a variety of ways: (1) for moving individuals from the storming phase to the norming phase and (2) for keeping the group steadily in the performing stage as examples. In addition to group development needs, there is also an individual motivational reason for team trust and cohesion. Schlossberg (1989) explains how individuals can be motivated by trust and cohesion or demotivated by a lack of trust and cohesion in her concepts of marginality and mattering.

According to Chaves (2006), Schlossberg defined marginality as a student who does not feel that they fit into the group. “Feelings of marginality can heighten students’ feelings of irritability or depression and can create unhealthy levels of self-consciousness when encountering new environments or taking on new roles and their accompanying expectations” (Chaves, 2006, p. 145). These feelings of being marginalized would likely hamper a student from learning or being motivated to learn from the other group members. Conversely, Schlossberg defined four dimensions to mattering: “(a) attention (a student feels noticed), (b) importance (a student feels cared about), (c) ego extension (a student feels that others will be proud of his or her accomplishments and sympathize with his or her failures), and (d) dependence (a student feels needed)” (as cited in Chaves
It is likely that these feelings of mattering would aid in an individual’s motivation to learn from the group through building greater trust and cohesion.

Team cohesion, as a concept, was first introduced by Festinger, Schachter, and Back (1950) as they were studying social pressures in informal groups. During their research, they determined that team cohesion was “the total field of forces which act on members to remain in the group” (p. 164). This definition has been accepted (Yalom, 1970; Evans & Jarvis, 1980; Evans, 1984) and criticized (Gross and Martin, 1952) for years. Festinger et al. (1950) describe some of the forces that act on members in the following quote:

Individuals may want to belong to a group because they like other members, because being a member of a group may be attractive in itself (for example, it may be an honor to belong to it), or because the group may mediate goals which are important for the members. (p. 22)

There are numerous reasons one might give for wanting to be in a group, and Festinger et al. (1950) would argue that the more attractive the group is to the individuals, the more they will want to remain in the group.

Gross and Martin (1952) point out that the difficult part of trying to achieve group cohesion is that the attractiveness of the group is based upon individual reason, and that no two individuals may have the same reason. They explain the connection between cohesion and attractiveness more fully in the succeeding quote:

The nominal definition, therefore, has as its crucial factor the attractiveness of the group for its members. It is clear that the same group may be highly attractive to its several members but for highly diverse reasons. The group may have a positive valence for member A because he has friends in it; for member B because he receives in the group approbation from other members; for member C because he believes in the program of the group; for member D because he has no place to go on Wednesday evening, and the group meets on Wednesday night; for member E because his father was a member of the group at one time, and he feels it is his
duty to belong; for member F because he thinks there are potential customers in the group for his business; for member G because he hates his wife, and the group gives him an excuse to leave his home one night a week; and for other members the group is attractive because it meets their peculiar and idiosyncratic needs. Further, since cohesiveness is viewed as the ‘total field of forces,’ the attractiveness of the group for any one member may be based on one or a combination of several or more factors. (pp. 547-548)

With such a never-ending field of possible influences on group cohesion, and with group cohesion being essential for groups to remain in the performing stage of group development, research into how to influence and achieve group cohesion was necessary.

To answer this need for research, Roark & Sharah (1989) set out to determine factors that are related to group cohesion. Roark & Sharah hypothesized that there were four inter-correlated factors that positively affected group cohesion. These factors were empathy, self-disclosure, acceptance, and trust. For the purpose of their research, they used Festinger et al.’s (1950) definition of group cohesion and operationalized the definition of empathy as an “understanding of the feeling and meaning of the member’s expressions and experiences and the ability to communicate this understanding (Carkhuff & Berenson, 1967)” (Roark & Sharah, 1989, pp. 62-63). They defined self-disclosure “as sharing ideas, feelings, and experiences for benefit of the members (Corey & Corey, 1982)” (Roark & Sharah, 1989, p. 63).

Roark and Sharah (1989) defined acceptance as team members accepting one another’s “feelings, values, and problems” (p. 63). Finally, they defined trust as “the sense of confidentiality and security of the members in the group (Corey & Corey, 1982)” (Roark & Sharah, 1989, p. 63). Roark and Sharah (1989) utilized survey research of three groups: (a) growth groups of master’s students involved in a course, (b) psychotherapy groups of patients, and (c) several groups of individuals enrolled in a DUI
course. As a result of the research, Roark and Sharah (1989) found that empathy, self-disclosure, acceptance, and trust are significantly inter-correlated and that empathy, self-disclosure, acceptance, and trust are also significantly correlated with group cohesiveness (p. 65).

In addition to Roark and Sharah’s work, McShane and Von Glinow (2009) point to six factors that influence team cohesion and further gain or build empathy, self-disclosure, acceptance, and trust. These six factors, which are remarkably close to Campion et al.’s (1996) team design elements, include: “member similarity, team size, member interaction, difficult entry, team success, and external competition or challenges” (McShane & Von Glinow, 2009, p. 155). McShane and Von Glinow’s list of factors can be seen in a variety of Tuckman’s stages, but, most definitely, they are heavily involved in the formation of the group.

McShane and Von Glinow (2009) utilize the term similarity-attraction effect to describe the concept of homogeneous groups. The authors argue that groups where people have similar backgrounds and values are more comfortable and attractive, which in turn encourages cohesiveness. In terms of team size, the authors share that smaller teams are usually found to be more cohesive than larger teams. They argue “it is easier for a few people to agree on goals and coordinate work activities” (McShane & Von Glinow, 2009, p. 155). However, McShane and Von Glinow submit that if the group is too small to achieve their tasks or goals, they will have less cohesion than a larger group.

The concept of member interaction and its effect on cohesion refers to the amount of times that members actually come into contact with one another. “Teams tend to have more cohesion when team members interact with each other fairly regularly. This occurs
when team members perform highly interdependent tasks and work in the same physical area” (McShane & Von Glinow, 2009, p. 155). Difficult entry refers to how selective or elite is the team that the member is joining. If the member believes that the team is prestigious, then he is more likely to be attracted to stay. With respect to team success, McShane and Von Glinow (2009) point out that individuals feel more cohesive towards teams that fulfill their goals (p. 156). McShane and Von Glinow (2009) go on to say “cohesion increases with the team’s level of success (Mullen & Copper, 1994).

Furthermore, individuals are more likely to attach their social identity to successful teams than those with a string of failures” (p. 156). Finally, and perhaps most closely tied to engineering competitions, we reach the concept of external competition and challenges. McShane and Von Glinow (2009) point out that both threats and friendly competition have been shown to bring group members together in an effort to overcome the challenge or defeat of the competition. Both Rempel and Fisher’s (1997) and Turner and Horvitz’s (2001) research found that one should employ caution when utilizing competition or threats as a cohesive technique. Both sets of authors found that if the threats or competition are perceived to be too severe or too stressful, teams will become prone to poor decisions and cohesiveness will wane.

Through an understanding of the development and sustainability of groups, as well as the characteristics of the individuals that make up groups, I will be more readily able to describe my subjects’ lived experiences in relation to social interactions that occur because of the group context of the engineering design competition.

Component 2: Authentic Focus
Returning to the earlier scenario of an individual learning to master a set of learning outcomes associated with a computer, imagine now if not only did the student learn through a project in a collaborative team but also that the scenario simulated an authentic, real-world scenario in which the individual would actually use a computer. It is the authentic scenario and focus which is the scope of this next section. Lombardi, (2007) explains the definition in this way:

> Authentic learning typically focuses on real-world, complex problems and their solutions, using role-playing exercises, problem-based activities, case studies, and participation in virtual communities of practice. The learning environments are inherently multidisciplinary. They are ‘not constructed in order to teach geometry or to teach philosophy. A learning environment is similar to some ‘real world’ application or discipline: managing a city, building a house, flying an airplane, setting a budget, solving a crime, for example’ (Downes, 2007). Going beyond content, authentic learning intentionally brings into play multiple disciplines, multiple perspectives, ways of working, habits of mind, and community. (pp. 2-3)

This definition of authentic-based learning is provided to help create an understanding of how authentic learning can be used and how engineering design competitions can have what Kearsley and Shneiderman (1998) called an authentic focus.

**Instructivist Activities versus Authentic Activities.** Reeves, Herrington, and Oliver (2002) compare an authentic-based learning approach to a more instructivist or teacher-centered approach where an activity is used:

> Under the influence of more ‘instructivist’ or teacher-centered approaches, activities were seen as a vehicle for practice. For example, in a systems approach to learning (such as Gagné, Briggs, & Wager, 1992) the activity or task that students do is described in a list of nine events of instruction as: ‘Eliciting the performance’, and is an opportunity for the student to show that he or she has mastered the skill and is able to demonstrate it to the teachers’ satisfaction. The systems model is based on a behaviorist approach and on the assumption that if skills and sub-skills are taught in the right order, in a systematic and comprehensive manner, then effective learning will occur. (p. 563)
For the purpose of comparing the two approaches, imagine a student learning outcome is that the student must be able to design a new engine for a motorcycle. In the real-world example, the students may start with nothing but the ill-defined problem of “you need to design a new engine.” In the real-world scenario, they may not get immediate feedback; the students may only be guided when they ask specific questions or at predetermined stages. The students are likely to be in a group, often interdisciplinary in nature. They are likely encouraged to go through the eight steps of the engineering design process which align well with Kolb’s (1984) five step experiential learning cycle. In the end, the students will test their prototype, communicate their solutions, and eventually redesign those items that did not work well and those that could be redesigned for human factors or efficiencies.

In comparison, a student who goes through a course on engine design that utilizes a more teacher-centered method would likely have a lesson or lecture on appropriate materials. There would be a class devoted to how to draw up plans; instructions on how to complete each of these steps would likely be provided to the group, presented in a lecture or conveniently found in a text book. The student could work independently or as a member of a group. To demonstrate their proficiency, they could be asked to take a test or, if the professor chose, they could be asked to complete a demonstrative assessment. In this assessment, they could be asked to put together their engine in front of the watchful eye of the professor. This professor might provide immediate feedback, such as “good job” or “no, not there . . . like this”, or, as a silent judge, marking down ways in which the student performed well or failed to follow a particular instruction.
Disadvantages of Instructivist Activities. Schön (1983) advanced the argument that with instructivist or teacher-centered instruction the content only goes as far as the teacher proposes and is limited to the ideas, dilemmas, and concepts that the professor proposes. In addition, the content is usually limited in its scope, often bent towards the faculty members prescribed ideologies and can often be “mastered” by memorizing content or formulas rather than knowing how and when to utilize the concepts and/or formulas in a real life scenario. Trilling and Fadel (2009) argue that the teacher-centered instruction creates a dependency on the instructor. This dependency manifests itself in the teacher being able to design or construct authentic scenarios that the students simply supply a memorized answer for the possible scenarios provided.

Duch, Groh, and Allen (2001) suggest that teacher-centered instruction simply cannot keep up with the demands and needs employers have for today’s graduate. They share a substantial list of metacognitive and social awareness skills that are necessary and cannot be taught by rote memorization and by plug and play formulas. These skills include communication, technology literacy, problem solving, adaptability in a diverse workforce, and completing a job in an ethical manner.

Finally, Lebow and Wager (1994) sum up the argument between authentic versus instructive learning in the following way:

It is an often-stated conviction that producing transfer is the main job of education. Yet, an increasing body of research shows that the way students learn something in school often results in students knowing something but failing to use it when relevant. Brown et al. (1989) have concluded that this condition, originally identified by Whitehead (1929) as the problem of inert knowledge and also referred to as a transfer problem, occurs because classroom learning environments generally lack the contextual features of real life problem-solving situations. (p. 232)
Within the preceding quote, Lebow and Wagner (1994) suggest that students are unable to make connections between what has been transferred or deposited and what they should comprehend. This suggestion is made because typically the classroom setting does not allow students to connect the learning to a real world context.

**Authentic Learning Effectiveness.** In contrast, Lombardi (2007) argues that authentic learning promotes what she labels as “portable skills” including: (a) judgment, (b) patience, (c) ability to recognize patterns in unfamiliar contexts, and (d) flexibility to work across cultural and disciplinary boundaries. She also provides an experiential learning argument for the benefit of authentic-based learning:

Learners look for connections: When we approach a subject for the first time, we immediately try to perceive the relevance of the new concept to our lived experience. When a new piece of information simply doesn’t fit in any of our existing knowledge structures (or ‘schemas’), it is often rejected. This means that the more encouragement a learner has to become invested in material on a personal level, the easier it will be to assimilate the unfamiliar. (Lombardi, 2007, p. 8)

Like Dewey (1938), Lombardi (2007) describes how essential it is to integrate current learning objectives into past learning experiences in such a way that new learning can be created and used in future settings.

**Characteristics of Authentic Activities.** In 2002, Reeves et al. presented ten characteristics that they synthesized from numerous studies. The ten characteristics have been nearly universally adopted in the authentic learning community, and they can be found referenced or adapted in multiple sites, from BIE.org, the online warehouse for all things project-based learning, to Educause’s white paper on the purpose of authentic-based learning. Reeves et al.’s (2002) characteristics have become a checklist for
teachers and instructional designers (Lombardi, 2007). They are presented below as an example of what should be present in order to ensure an authentic focus.

**Real-world relevance.** Reeves et al. (2002), citing the works of Lebow and Wager (1994), Cronin (1993), Jonassen (1991), Young (1993), and others, explain that in order to be authentic, the activities involved in the learning must be designed to be as close to the real-world tasks as possible. Reeves et al. warn against creating a decontextualized or classroom-based task. Anderson, Reder, and Simon (2000) invoke Piaget and Lewin when they call this an action that is grounded in concrete situations. Anderson et al. (2000) and others share the belief that contextual learning cannot occur independently of the real-world situation.

**Ill-defined activities.** An authentic task does not provide all of the answers, nor does it provide a lock step pattern that should be followed; instead, the activity is purposefully ill-defined. According to Sternberg, Wagner, and Okagaki (1993), Lebow and Wager (1994), Bransford, Vye, Kinzer, and Risko (1990), and others, this ill-defined activity will require students to define for the group what needs to be done, the steps that should be taken to accomplish the task, and force them to sequence the tasks that should be accomplished. In addition, an ill-defined project often will allow a group to have numerous ways that they can solve for the issue. This openness to multiple interpretations is another purposeful trait that is born from ill-defined activities.

**Complex tasks over a sustained period of time.** Reeves et al. (2002), quoting the work of Bransford, Vye, et al. (1990), Jonassen (1991), Lebow and Wager (1994), and others, indicate that activities should not be simplistic; they should take days, weeks, and months to complete, rather than minutes or hours. This provides the time for the group to
go through Tuckman’s (1965, 1977) stages as well as for Lombardi’s (2007) learning outcomes, like patience and diversity, to take hold. Berliner (1992) reminds us of the somewhat obvious statement that real-life projects frequently have depth, difficulty, and take time to solve. In order to be as authentic as possible, the situations that students face in authentic learning should also be in-depth, difficult, and take time to solve.

**Different perspectives, using a variety of resources.** Another of Reeves et al.’s (2002) characteristic of an authentic activity is one where students are afforded the opportunity to look at a problem from differing viewpoints, perspectives, and from different disciplines. Pea (1993) maintains that to solve real life projects and perform real-world activities, it can take multiple people and multiple people’s backgrounds, experiences, and intelligence. This trait is often why authentic learning is done in a multidisciplinary environment.

**Collaboration is integral.** Collins, Brown, and Newman (1989) point out that real-world problems do not always have solutions or explanations. Often, an individual learner will not be capable of coming to a solution or an answer. However, within a collaborative environment, a solution can more likely be achieved. Reeves et al. (2002) state that authentic activities provide the opportunity to collaborate, while Gordon (1998) argues that authentic activities, done in teams, are one of the best ways to develop solutions to increasingly complex and uncertain challenges.

**Opportunity to Reflect.** By virtue of being experiential in nature, authentic activities provide the opportunity to reflect. Reeves et al. (2002) contend that authentic activities provide this opportunity, and Wood-Daudelin (1996), quoted below, makes the argument that guiding the process of reflection can enrich learning:
Reflection is a highly personal cognitive process. When a person engages in reflection, he or she takes an experience from the outside world, brings it inside the mind, turns it over, makes connections to other experiences, and filters it through personal biases. If this process results in learning, the individual then develops inferences to approach the external world in a way that is different from the approach that would have been used, had reflection not occurred. While the catalyst for the reflection is external, and while others may help in the process by listening, asking enabling learners to questions, or offering advice, the reflection occurs within the mental self.

Reflection and learning may therefore be defined in this context as follows: Reflection is the process of stepping back from an experience to ponder, carefully and persistently, its meaning to the self through the development of inferences; learning is the creation of meaning from past or current events that serves as a guide for future behavior. (p. 39)

**Interdisciplinary perspectives.** Reeves et al. (2002), quoting Bransford, Sherwood, Hasselbring, Kinzer, and Williams (1990), Bransford, Vye et al. (1990), and Jonassen (1991), point out that authentic activities should integrate different subject areas and multiple domains into the outcomes of authentic based learning. Real-world projects rarely can be completed by one individual or one department and often take interdisciplinary perspectives rather than one perspective or one domain’s process.

Hackett and Rhoten (2009) share that interdisciplinary work comes with a number of challenges, including different standards that must be met by different disciplines, different language that is used by students and professionals in different disciplines, and different ways of assessing success. When considering Hackett and Rhoten’s concerns, it makes even more sense to learn lessons of this sort in an authentic activity where terms, meanings, and requirements can be worked out in a real-world environment without real-world catastrophic consequences.

**Seamlessly integrated assessment.** Reeves and Okey (1996), Young (1995), and Reeves et al. (2002) advance the point that authentic activities are their own assessment.
If the student outcome is to create a computer program that automates the process of turning off lights, an authentic project with an outcome of running a computer program that turns out the lights is integrated with the project. However, in instructive based learning, the assessment in the form of a test would be separated into how someone might code the software and then separate questions for what might go wrong, what might not be efficient or other probes. Reeves et al. (2002) call this artificial assessment as it is removed from the nature of the task.

**Complete products.** Reeves et al. (2002) share that authentic activities should create finished projects rather than preparing portions of the project in an assembly line fashion. Gordon (1998) agrees with Reeves et al. when he states:

After completion and exhibition of their products, the students are not ‘done’ with their learning. Students participate in the reflection phase, in which they examine their work and reflect on what they have learned (reinforcing and constructing knowledge and considering their personal and interpersonal behaviors). Students may then join the teacher in assessment of their work based on their pre-established standards of quality. (p. 392)

Gordon (1998) explains that the importance of reflection is to ensure that students can see the process all the way through, that they can reflect on each step of the process, and so that they can consider what they have learned in each phase of the project.

**Competing solutions and diverse outcomes.** To round out their ten necessary characteristics of authentic activities, Reeves et al. (2002) share that authentic activities should allow numerous, even contradictory or competing, solutions. The mantra for each of the ten characteristics has been that authentic activities should be as close to a real-world scenario as possible. What could be truer than the fact that there are multiple solutions and diverse outcomes to a problem? To utilize a real-world, multi-billion dollar
industry, consider mobile communication devices. When asked to design and create a telephone, the multidisciplinary team at Apple has created a very different solution in the iPhone, especially when comparing the iPhone touch-screen keyboard system to the Blackberry and its Qwerty style keyboard. Even with these very different solutions, both companies have made hundreds of millions of dollars, annually. In authentic-based learning, authors such as Bransford, Sherwood, et al. (1990), Bransford, Vye et al. (1990), and Bottge and Hasselbring (1993), advocate for authentic activities that lead to numerous solutions. A second benefit to having multiple outcomes and solutions is that the group must then learn to compromise, communicate, and come to consensus of how they will choose to solve the problem. These actions again lead back to Lombardi’s (1997) portable skills.

**Authentic focus for an engineering design competition.** Engineering Design curriculum is full of potential learning outcomes that would benefit from an authentic activity. A review of the Accreditation Board for Engineering and Technology’s (ABET) student learning outcomes associated with engineering design reveals a number of “portable skills” as well as discipline specific skills. Palmer, Terenzini, McKenna, Harper, and Merson (2011) provide a comprehensive list of ABET student learning outcomes that include the following:

- an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
- an understanding of professional and ethical responsibility
- the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
- a knowledge of contemporary issues. (Palmer et al., 2011, p. 1)
Palmer et. al.’s (2011) student learning outcomes are just an example of those which lend themselves to authentic activities.

**Component 3: Project-Based Learning**

Project-based learning is essentially an assigned project that requires a solution to a problem, can be done singularly or in a group, and will result in some product, such as a report, program, model, or other tangible item (Helle, Tynjälä, & Olkinuora, 2006). Project-based learning can be implemented in a variety of environments including individual courses across the curriculum (Heitmann, 1996) and as co-curricular experience (Hill, 2006).

**Characteristics of Project-Based Learning.** A framework of project-based learning that has stood the test of time is Adderley et al. (1975). They offer five characteristics that define whether a project is worthy of being called project-based learning. According to Adderley et al., the five characteristics are as follows:

- projects involve the solution of a problem; often, though not necessarily, set by the student himself or herself;
- they involve initiative by the student or group of students, and necessitate a variety of educational activities;
- they commonly result in an end product (e.g. thesis, report, design plans, computer program and model);
- work often goes on for a considerable length of time;
- teaching staff are involved in an advisory, rather than authoritarian, role at any or all of the stages- imitation, conduct, and conclusion. (as cited in Helle et al., 2006, p. 288)

Faculty may utilize this list in order to ensure that they are creating an appropriate project that promotes optimal learning.

**Authentic Project-based learning.** Mapping Adderley et al.’s (1975) work to Reeves et al.’s (2002) ten characteristics of an authentic activity provide a clear
understanding of how project-based learning can be an authentic based activity. This assertion is also backed by a number of other authors and researchers (Blumenfeld et al., 1991; Savery & Duffy, 1995; Thomas, 2000).

**Faculty-Centered versus Learning-Centered.** In order to claim that project-based learning is both experiential and authentic, it would also be necessary to ensure that the project is learning-centered in nature. Helle et al. (2006) point out that not all project-based learning assignments are learning-centered. Helle et al. (2006) categorize projects three ways. The first type is a project exercise, which aims to demonstrate student’s prior knowledge about topics that are already familiar to them. The projects are guided by the content and curriculum that are chosen by the professor. The second type is project component; Helle et al. (2006) describe this type of project work as having broader scope, being more interdisciplinary, and relating to “real world” issues. They also describe the objectives or end goals as resolving a problem. The final category is project orientation. Helle et al. (2006) share that this project is pervasive throughout the entire curriculum and also share that the instruction received is to augment the project the student has chosen:

Project exercises are typically a part of teacher-centered project pedagogy. The project exercise is the ‘capstone’ event designed to integrate the subject material learnt during a specific course. On the other hand, project components and project orientation tend to leave more scope for student centeredness. However, project components and project orientation can also be work-based, which serves to introduce an extra element into the control in the learning process. Ideally, this results in a three-way partnership between the client, the student and the teacher. (p. 289)

Ultimately the behavior and the choices that the professor makes dictate whether or not the project within the course, or in the co-curriculum, is faculty-centered or learning-centered.
Benefits of Project-Based Learning. Numerous researchers have shared benefits that relate to project-based learning, some of which are related to working with a project. Some benefits come because the activity is authentic, and others are due to the collaborative nature of the learning. A sampling of the benefits and the research that bore the findings include: Thomas (2000), who found that project-based learning leads to growth in self-reliance and improved attitudes toward learning; Boaler (1999), who found that students had an academic gain equal to or better than those who were taught by other models; and Railsback (2002), who found that project-based learning provides a strategy to engage students in culturally diverse learning opportunities.

However, Intel® Teach Program, a partnership between educators and the Intel® Corporation, adds that project-based learning goes beyond just the twenty-first century skills like communication, diversity appreciation, personal responsibility, and critical thinking. Intel® (2007) argues that:

Well-designed projects encourage active inquiry and higher-level thinking (Thomas, 1998). Brain research underscores the value of these learning activities. Students' abilities to acquire new understanding are enhanced when they are ‘connected to meaningful problem-solving activities, and when students are helped to understand why, when, and how those facts and skills are relevant’ (Bransford, Brown, & Conking, 2000, p. 23). (p. 1)

According to Bransford, Brown and Conking’s (2000) quote, project-based learning has many of the same benefits as authentic-based learning. In addition to the benefits, they point out that there are similar requirements to acquire those benefits. For instance, students must connect the meaning to something real-world and contextual.

According to Fleming (2000), the benefits of project-based learning can be enjoyed by every academic status because the process is designed to put learning into a
context that gives meaning to the students who are participating in the project. Fleming (2000) points out that, regardless of differences in intelligences, learning preferences, or learning styles, project-based learning can increase learning, motivation, and student interest.

**Self-directed learning.** Another key benefit of project-based learning is that it promotes the concept of self-directed learning. “A key result of all of the PBL activities is to enable students to develop self-directed learning capabilities. After all, the purpose of education is not to transmit ‘what to know’ but to challenge students to develop the skills of inquiry or ‘how to learn’” (Savage, Vanasupa, & Stolk, 2007, p. 2).

According to Knowles, self-directed learning is a process “in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes” (as cited in Savage et al., 2007, pp. 2-3).

Knowles’ (1975) popularized a four-step process for self-directed learning that seems to map well with both Adderley et al.’s (1975) project-based learning model and Reeves et al.’s (2002) ten characteristics of an authentic activity. Knowles’ four steps include: (a) diagnose & formulate learning needs, (b) identify resources for learning, (c) choose and implement learning strategies, and (d) evaluate learning outcomes (as cited in Savage et al., 2007, p. 3).

Harding, Vanasupa, Savage, and Stolk (2007) realized that self-directed learning is often cited as a key outcome required in engineering education. They set out to determine the relationship between self-directed learning and student motivation within
engineering project-based learning programs. What they found was that there was no change in a student’s grade motivation, which Deci (1975) would call an external motivator, but they did find a correlation between the project-based learning and the student’s internal motivation to learn for personal growth. They were then able to find a strong correlation between this internal motivation and self-directed learning. Harding et al. (2007) went on to make the comparison between project-based learning, as a promoter of internal motivation to learn and self-directed learning, versus traditional coursework. The comparison was not found to promote the motivation to learn or for self-directed learning but promoted only externally regulated behavior due to grades.

**Facilitating Self-Directed Learning.** While self-directed learning is one of the key benefits of both project-based learning and andragogy, the role of an educator is still essential to the learner’s success. Sanford (1966, 1967) suggests that three conditions are essential for student growth and development. Sanford’s suggested conditions include: (a) readiness, (b) challenge, and (c) support (Hamrick, Evans, & Schuh, 2002).

According to Hamrick et al., readiness is a condition to which both the educator and the student contributes. The student must be ready to learn, prepared to do so, free from distractions, and physically and mentally available. Hamrick et al.’s description of readiness harkens back to Maslow (1943) and his belief that the student’s lowest needs must be meet so that they can achieve the highest need of self-actualization. The aspect of readiness that the educator contributes to is assisting with creating a beneficial learning environment.

Sanford’s (1966, 1967) next two conditions involve how the educators deliver the support they give to the students. Sanford (1966, 1967) believed that in order for
development to occur, there needed to be a balance between the amount of challenge that an educator provided to students and the amount of support provided. Hamrick et al. (2002) write about Sanford’s belief in challenging and supporting students:

For a change to occur, there must be internal or external stimuli which upset [the student’s] existing equilibrium, which cause instability that existing modes of adaptation do not suffice to correct, and which thus require the person to make new responses and so to expand his [sic] personality. (p. 82)

Hamrick et al. (2002) are pointing out that there must be a challenge which causes the student to rethink their preconceived notions about a subject. They also warn if there is too much dissonance, the student may become disenfranchised and alienated. The result may be that students turn to bad habits, poor choices, ignore the challenge, or drop out of the environment altogether. Hamrick et al. go on to point out that too little challenge may be comfortable or enjoyable for the student, but that learning, growth, and development will not occur.

Project-based learning, experiential learning, and collaborative learning each provide numerous ways in which a student can be challenged. For example, students can be asked to support their point of view to the group. Or the educator may not provide an answer to a question, instead providing support by only providing a path for how the students can find the answer themselves. Within the group dynamics environment, there are other ways challenges can occur. For instance, group members often will be required to compromise, a skill that will create both growth and authenticity.

To balance challenge, Lowry (1989) offers 20 ways in which educators can support self-directed learning. Of the 20 suggestions, the following 12 are the most relevant to educators involved with engineering design competitions: (a) help the learner
identify the starting point for a learning project and discern relevant modes of
examination and reporting; (b) create a partnership with the learner by negotiating a
learning contract for goals, strategies, and evaluation criteria; (c) be a manager of the
learning experience rather than an information provider; (d) help learners acquire the
needs assessment techniques necessary to discover what objectives they should set; (e)
encourage the setting of objectives that can be met in several ways and offer a variety of
options for evidence of successful performance; (f) provide examples of previously
acceptable work; (g) make sure that learners are aware of the objectives, learning
strategies, resources, and evaluation criteria once they are decided upon; (h) teach inquiry
skills, decision making, personal development, and self-evaluation of work; (i) help
match resources to the needs of learners; (j) help learners locate resources; (k) use
techniques such as field experience and problem solving that take advantage of adults'
rich experience base; and (l) create an atmosphere of openness and trust to promote better
performance (Lowry, 1989, pp. 3-4).

**Project-based Learning as a component of Engineering Curriculum.**
According to Newberry and Fowler (1992), quoting Wickerenden (1926) and Walker
(1989), engineering curriculum is made up of three principles: (1) the control and
utilization of the forces, materials, and energy of nature, (2) the organization of human
effort for these purposes, and (3) the estimation of costs and appraisals of values, both
economic and social, involved in these undertakings. Alternatively, it has been said that
the art of engineering is to take a bright idea, and with money, manpower, and materials,
produce something that the public wants at a price it can afford to pay, with proper regard
for the environment (p. 2).
In order for students to learn or understand these three principles, engineering curriculum has evolved over the years into a number of courses, or learning outcomes, which cover these principles. One of those courses and sets of learning outcomes that have evolved are known as engineering design, described by Okudan et. al. (2011) as follows:

The Accreditation Board for Engineering and Technology (ABET, Inc.) defines design as —the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and the engineering sciences are applied to convert resources optimally to meet these stated needs. A similar definition comes from Clive Dym et al.: —Engineering design is a systematic, intelligent process in which designers generate, evaluate, and specify concepts for devices, systems, or processes whose form and function achieve clients’ objectives or users’ needs while satisfying a specified set of constraints (p. 104). (p. 2)

From this definition, it is obvious that engineering design can easily be an authentic activity that meets all three principles of engineering that were recognized by Newberry and Fowler (1992).

There have been numerous ways in which faculty have chosen to instruct, teach, or guide students to understand the learning outcomes associated with engineering design. However, for the purpose of this dissertation, we will focus on project-based learning and specifically on engineering design competitions.

**Why project-based learning as a delivery method for engineering design.** As stated by Thomas (2000), Boaler (1999), Railsback (2002), Lombardi (2007), and so many others, collaborative, authentic, and project oriented activities promote what Miles and Wilson (2004) call twenty-first century skills: communication, computation, citizenship, critical thinking, interpersonal, and technology. Throughout this dissertation, I have shown that experiential, collaborative, authentic, and project oriented activities
such as engineering design competitions have a better track record of achieving these outcomes than traditional piecemeal education.

**Engineering as a profession values twenty-first century skills.** Zhang and Zhang (2011) and Mills and Treagust (2003) are just a few of the engineering authors who speak to the need of these twenty-first century skills. Zhang and Zhang (2011) share that the engineering profession should strive to recruit not only those professionals who are talented engineers and scientists, but also those individuals who are strong collaborators, communicators, and have the ability to deal with work related relationships. Mills and Traegust (2003) make the following argument:

In recent years studies have been conducted in many countries to determine the technical and personal abilities required of engineers by today’s industry (e.g. [1], [2]). These studies have indicated some key concerns. Today’s engineering graduates need to have strong communication and teamwork skills, but they don’t. They need to have a broader perspective of the issues that concern their profession such as social, environmental and economic issues, but they haven’t. Finally, they are graduating with good knowledge of fundamental engineering science and computer literacy, but they don’t know how to apply that in practice. (p. 2)

Mills and Traegust clearly make the case for how twenty-first century skills are important for future engineering professionals.
CHAPTER 3

METHODOLOGY

If there were only one truth, you couldn’t paint a hundred canvases on the same theme.
~ Pablo Picasso

As is stated in chapter one and reiterated throughout chapter two, the purpose of this dissertation is to describe the lived experiences related to motivation for competitors of International Robosub and Roboboat Competitions at a selective engineering university and to provide educators and administrators with a better understanding of how to use engineering competitions to motivate their students to learn the design process. In order to accomplish this purpose, a phenomenological study, using in-depth interviews and document/artifact analysis, was conducted.

To guide the study, the following grand tour question was utilized: While preparing for and participating in International Robosub or Roboboat Competitions, what experiences – actual acts, specific behaviors, or other moments bring about the feeling of motivation for student contestants? To gain this information, the following sub-questions were explored:

1. How do student contestants describe their motivation and ascribe meaning to it personally?
2. In what context does motivation occur to them, individually and in interaction with others?
3. Who helped bring about motivation for these student contestants?
4. In what ways does this motivation propel them to act, learn, or achieve?

Research Paradigms

Within the world of research, two different approaches have emerged: quantitative and qualitative approaches. Over the last half century and beyond, there have been debates and discussions of the benefits and faults of each paradigm. Today, many have moved past the concept of one preferential paradigm and have instead headed the words which Merton and Kendall (1946) pointed out, so long ago, “Social scientists have come to abandon the spurious choice between qualitative and quantitative data; . . . The problem becomes one of determining at which points he should adopt the one, and at which the other, approach” (pp. 556-557).

Understanding when to adopt qualitative or quantitative methods is often a basic learning outcome for any discipline’s research methods course. According to Creswell (2012), it is the nature of the research problem and the research questions that dictate which paradigm should be chosen, communicating in these words:

The problem, the questions, and the literature reviews help to steer the researcher toward either the quantitative or qualitative track. These, in turn, inform the specific research design to be used and the procedures involved in them, such as sampling, data collection instruments or protocols, the procedure the data analysis and the final interpretation of results. (p. 11)

In this quote, Creswell (2012) states that the type of research and the research question itself guide the researcher to one of the two research paradigms, taking preference or opinion out of the process.

One of the best ways to come to an appreciation for each of the two paradigms is to understand the characteristics of each. Creswell (2012) suggests that quantitative
research has the following characteristics: (a) describing a research problem through a
description of trends or a need for an explanation of the relationship among variables; (b)
providing a major role for the literature through suggesting the research questions to be
asked and justifying the research problem and creating a need for the direction (purpose
statement and research questions or hypotheses) of the study; (c) creating purpose
statements, research questions, and hypotheses that are specific, narrow, measurable, and
observable; (d) collecting numeric data from a large number of people using instruments
with preset questions and responses; (e) analyzing trends, comparing groups, or relating
variable using statistical analysis, and interpreting results by comparing them with prior
predictions and past research; and (f) writing the research report using standard, fixed
structures and evaluation criteria, and taking an objective, unbiased approach (p. 13).

An additional way to appreciate quantitative research is to understand what types
of questions the paradigm can help answer. Johnson and Christensen (2003) believe that
the essence of quantitative research is in answering one of three types of questions: (a)
descriptive questions that ask, “How much?”, “How often?”, or “What changes?”; (b)
predictive questions which seek to determine if a predictor variable leads to an outcome
variable; or (c) causal questions which attempt to compare variables after a manipulation
or change.

Qualitative methods, on the other hand, have different characteristics and provide
researchers with tools to answer a different type of question. Creswell (2012) lists the
following characteristics of qualitative research: (a) exploring a problem and developing
a detailed understanding of a central phenomenon; (b) having the literature review play a
minor role but justify the problem; (c) stating the purpose and research questions in a
general and broad way as to the participants’ experiences; (d) collecting data based on phrases from a small number of individuals so that the participants’ views are obtained; (e) analyzing the data for description and themes using text analysis and interpreting the larger meaning of the findings; and (f) writing the report using flexible, emerging structures and evaluative criteria, and including the researcher’s subjective reflexivity and bias. Griffiths (1996) shares that the questions that are often answered by qualitative research include items that will assist in “understanding phenomenon for which, at present, we have no really good working models, for example, why people do not take prescribed drugs as intended by the doctor” (p. 27).

Because the focus of this dissertation is to gain insight, explore, or seek to understand, Creswell (2012) shares that it is characteristic of qualitative research. In addition, Creswell offers four other standards that would indicate if a researcher should use a qualitative methodology; these standards include the following: (a) if the problem requires you to learn about the views of individuals, (b) assess a process over time, (c) generates a theory based on participants’ perspectives, or (d) obtain detailed information about a few people or research sites. Given that the research problem for this dissertation meets nearly all of Creswell’s standards, it becomes readily apparent why a qualitative methodology will be utilized.

Utilizing Lester (1999) and Groenewald (2004), I determined that an explorative research design was necessary to answer my research question. Specifically, I found Lester and Groenewald’s use of phenomenology in their studies of collaborative education to be the most appropriate design. Because I conducted an in-depth exploration of the type of motivation that students experience, the most appropriate
method was experiential phenomenological research. “Pure phenomenological research seeks, essentially, to describe, rather than explain, and to start from a perspective free from hypotheses or preconceptions (Husserl, 1970)” (as cited in Lester, 1999, p. 1).

**Conceptual Framework**

Maxwell (1998) points out, “One of the critical decisions that you will need to make in designing your study is the paradigm (or paradigms) within which you will situate your work. This use of the term ‘paradigm,’ which derives from the work of the historian of science, Thomas Kuhn, ‘refers to a set of very general philosophical assumptions about the nature of the world (ontology) and how we can understand it (epistemology), assumptions that tend to be shared by researchers working in a specific field or tradition’” (pp. 223-224).

The paradigm that was utilized to guide this dissertation is constructivism, which is sometimes called naturalistic inquiry. “Constructivism as a paradigm or worldview posits that learning is an active, constructive process. The learner is an information constructor. People actively construct or create their own subjective representations of objective reality. New information is linked to prior knowledge, thus mental representations are subjective” (Learning Theories, n.d., para. 1).

Cobern (1993) provides a narrative description to help formulate an understanding of the paradigm:

We all wish to know about the world around us, whether we are speaking of the world in physical, social, or even spiritual terms. In science, one uses the senses of sight, hearing, touch, and taste to learn about physical phenomena. Instruments are used to extend the range of the basic human senses. These instruments can be as simple as an ordinary ruler or as complex as a radio telescope or mass spectrometer. Typically what we have thought in science is that our senses
provide authentic data about the real world. Experimentation keeps subjectivity in check. But is that really how our senses work? Consider that science uses the senses to focus only on what can be measured. For example, a scientist typically is not nearly as interested in the color of an object as he or she is in measurable electromagnetic wavelengths emitted or reflected by the object. If you want to build a color television, knowledge of electromagnetic wavelengths is necessary. However, who can say that a wavelength of $4.0 \times 10^{-7}$ m tells us any more about the reality of an object than does blueness? In fact, philosophers of science tell us that the question cannot be answered. Scientists focus on measurable attributes simply because they have chosen to do so—it works for what they want to do. (p. 106)

Cobern’s (1993) quote reminds us that there are many different backgrounds and contexts which one can use to look at the world. While utilizing a different lens will result in different answers and different insights into a subject, no one insight necessarily is better than another or more correct. However, some insights are more appropriate for certain questions. Cobern’s quote reiterates Creswell’s (2012) earlier quote that the research question dictates the research paradigm and methodology.

**Phenomenological Orientation**

When undertaking a phenomenological study, a researcher must consider the philosophical underpinnings of the different orientations or schools of phenomenology. There are multiple schools of phenomenology with different authors assigning different titles or names to the same orientations; for instance, experiential phenomenology is also labeled phenomenology of practice.

In an attempt to both understand a variety of phenomenological approaches and to choose the most appropriate types, I reviewed multiple schools of phenomenological thought outlined by van Manen (2011c). The first is transcendental phenomenology, which is the original philosophical branch of phenomenology. Transcendental phenomenology is described as “the special method of the eidetic reduction by means of
which the phenomena are described” (van Manen, 2011c, para. 1). Contrary to transcendental phenomenology’s epistemological purpose, existential phenomenology, in contrast, is ontological in nature and studies the concept of free choice and how we act in concrete situations (Smith, 2011). Hermeneutical phenomenology, on the other hand, uses texts, verbal language, and/or a variety of other media in order for the researcher to make meaning of the subject’s act of interpreting. This gives the hermeneutical researcher a look at how people go about understanding the world in which they exist. For this line of research, it is the subject’s interpretation of their lived event that is researched instead of the lived experience itself (Cohen, Kahn, & Steeves, 2000). There are a number of additional phenomenological orientations. One such orientation is linguistical phenomenology, which is based upon Blanchot, Derrida and Foucault’s work in French linguistics (van Manen, 2011b). Other orientations include ethical phenomenology, naturalistic phenomenology, social phenomenology, and genetic phenomenology. Regardless of which orientation a researcher chooses as a framework for their research, the one aspect that each of these orientations share is their effort to remove anything that represents a prejudgment or presupposition (Moustakas, 1994).

Phenomenology requires a researcher to look at things tabula rasa. Meaning is then discovered or created when the subject of the research provides a form of expression which is then interpreted and assigned a meaning. “What appears in consciousness is an absolute reality while what appears to the world is a product of learning” (Moustakas 1994, p. 27).

Since the topic is one of an andragogical nature, and because I approached this dissertation from the perspective of a practitioner rather than that of a philosopher, it
made sense to follow the advice of van Manen (2011a). This advice suggested that I choose the experiential phenomenology or the phenomenology of practice as the dissertation’s conceptual framework. Experiential phenomenology has a basis in the work of Kurt Lewin’s field theory (1946, 1951) and Kolb’s experiential learning theory (1975, 1984). It is characterized by the researcher’s goal of understanding everyday practices.

A phenomenology of practice is challenged to free itself of calculative rationality. In fact, the primal or pre-theoretical dimensions of practice are tied into the ontology of being and knowing. What distinguishes practice from theory is not that practice applies thought or concepts technically to some real thing in the world upon which it acts; rather, the phenomenology of practice involves a different way of knowing the world. Whereas theory "thinks" the world, practice "grasps" the world—it grasps the world pathically (van Manen, 1997; 1999). In terms of pathic knowledge, van Manen (2007) refers to the “general mood, sensibility, sensuality, and felt sense of being in the world” (pp. 20-21).

In addition to this orientation, Giorgi (2006) suggested that I also approach this orientation from my own discipline as an educator.

We (Giorgi, 1985) ourselves have proposed that a disciplinary attitude be adopted within the context of the phenomenological attitude that also has to be adopted. Thus, if one is a nurse, then a nursing attitude should be adopted and if a psychologist, then a psychological attitude is required, and so forth. The adoption of the disciplinary attitude brings the proper sensitivity to the analysis and it provides a perspective that enables the data to be manageable. (Giorgi, 2006, p. 354)

Giorgi makes this recommendation because he believes that one’s own disciplinary attitude serves as a framework of sorts. Giorgi (2006) states that “without the strict application of a delineated perspective one can be pulled all over the lot” (p. 354). As an
educator, I utilized motivational theories and educational methods such as experiential, cooperative, authentic, and project-based learning within the context of the phenomenological attitude to keep me grounded and prevent me from losing focus of my research purpose.

Moustakas’ Methodological Procedure

The methodological procedure that I used for this study is from Moustakas (1994) and includes the following steps: (1) discovering a topic and question rooted in autobiographical meanings and values, as well as involving social meanings and significance; (2) conducting a comprehensive review of the professional and research literature; (3) constructing a set of criteria to locate appropriate co-researchers; (4) providing co-researchers with instructions on the nature and purpose of the investigation, and developing an agreement that includes obtaining their informed consent, insuring confidentiality, and delineating the responsibilities of the primary researcher and research participant, consistent with ethical principles of research; (5) developing a set of questions or topics to guide the interview process; (6) conducting and recording a lengthy person-to-person interview that focuses on a bracketed topic and question. A follow-up interview may also be needed; and (7) organizing and analyzing the data to facilitate the development of individual textural and structural descriptions, a composite textural description, a composite structural description, and a synthesis of textural and structural meanings and essences (pp. 103-104).

Transcendental Principles

As stated above, I used an experiential phenomenology. I also utilized Lewin (1951) and Kolb (1984) as guides to my questions and interpretations. However, there
are some principles from transcendental phenomenology which are so important to and
gained in the methodology of phenomenology that they cannot be overlooked. These
principles are essential in order to fulfill steps four through seven of the Moustakas
method that I have identified above. These transcendental principles are: (a)
acknowledge the difference, and correctly use noema and noesis; (b) achieve epoch; (c)
bracket any preconceived notions; and (d) enter phenomenological reduction.

**Noema and Noesis**

Sokolowski (2000) describes noema and noesis in every day terms as two
different attitudes or perspectives that all phenomenological researchers must
acknowledge. This acknowledgement and the subsequent reflection come with an
understanding of the differences between two states of an object. Sokolowski (2000)
calls these two states the natural attitude and the phenomenological or transcendental
attitude. Moustakas refers to them, as Husserl (1931) introduced them, as nomea (natural
attitude) and noesis (phenomenological attitude).

Sokolowski (2000) described natural attitudes as the objects, things, and situations
around us. The natural attitude sees these items or things as tangible or concrete, and the
way we describe the item reflects that. Moustakas (2004) explains that “nomea involves
the internal perception, appearance, and experience working together to capture the
meaning” (p. 71). While transcendental or noesis “refers to the act of perceiving, feeling,
thinking remembering, or judging, all of which are concealed and hidden from
consciousness. The meanings must be recognized and drawn out” (Moustakas, 2004, p.
69).
To illustrate, imagine that I am interviewing a student about his experience participating in Habitat for Humanity. To evoke stories, I use the student’s hammer as a visual cue. To a student utilizing a natural attitude or nomea, he might provide a story of how he used a hammer as a tool to strike nails into wood. However, if that same student is in the phenomenological attitude, the hammer could evoke a story about how he has the ability to make a difference in the world, or it could represent to the student a story of a family that was rocked by tragedy but now has choices and a new lease on life.

Both the noesis and the nomea constitute an item, object, or an experience’s meaning. Moustakas (2004) states that all things have a noesis and a nomea; the meaning of both constitute its full meaning. He also shares that the meaning will be different for different people. Moustakas (2004) even goes as far as to say that the noesis can be very different for one person, depending on the emotions and the attitude of the person on the day that they are asked. He gives the example that the noesis will be different for someone that has confidence than if the person was lacking confidence at that moment.

Acknowledging and reflecting on the fact that all experiences have two meanings, both a natural attitude and a phenomenological attitude, allowed me to reflect on how I wrote my questions and how I conducted my interviews. It was my intention to probe during my interviews for the noesis and not to suggest one of my own.

**Epoche**

Schmitt (1968) describes achieving epoche as the state of setting aside our “prejudgments, biases, and preconceived ideas” (p. 59). He goes on to suggest that we must “invalidate, inhibit, and disqualify all commitments with reference to previous knowledge and experience” (Schmitt, 1968, p. 59).
Husserl (1931) provided the following quote as a step for removing all bias and adding researcher validity to the process of phenomenology:

All sciences which relate to this natural world, . . . though they fill me with wondering admiration, . . . I disconnect them all, I make absolute no use of their standards, I do not appropriate a single one of the propositions that enter into their systems, even though their evidential value is perfect. (p. 111)

In the sense of how this fits into the methodology of my dissertation, striving to achieve epoche prevented me from making assumptions about a particular story and assigning it a particular motivational theory. For instance, if a student sharing an experience of how the competition has helped to add to his motivation to learn, and I were to immediately jump to the conclusion that this student must be motivated by a reward and thus is influenced by behaviorism, I may inadvertently steer the conversation away from how the student was actually motivated to win. Perhaps, he wanted to prove to everyone that he was not a failure or that he does have the intelligence to be an engineer. This motivation perhaps would be much more in line with achievement theory or, perhaps, some other form of motivation not yet described.

**Bracketing**

One of the requirements for achieving epoche is to bracket any preconceived notions. In my earlier described scenario of interviewing an engineering design competitor, I would need to bracket the preconceived notion that competitions, for example, mean reward. While this may be true for me, it could be an entirely different meaning or noesis to the person that I am interviewing. Sokolowski (2000) describes bracketing as taking away all noesis from an item and leaving it only with its naturalistic form, or its nomea. This prevents the researcher from assigning it their own noesis. It
allows the subject being interviewed the opportunity to provide their meaning to both their nomea and their noesis. Moustakas (1994) points out:

The Epoche gives us . . . clearing of the mind, space, and time, a holding in abeyance of whatever colors the experience or directs us, anything whatever that has been put into our minds by science or society, or government, or other people, especially one’s parents, teachers, and authorities, but as one’s friends and enemies. (p. 86)

A number of critics argue that bracketing, reduction, and epoche are often ignored or misapplied. LeVasseur (2003) blames vagueness of the terms and the lack of researchers and methodologists explaining how it should work as why bracketing is often not employed. Giorgi (2006) emphasizes that researchers often only give epoche, bracketing, and reflexivity, lip service and never actually utilize the techniques. “The basic principles of phenomenology are often cited correctly but they are not fully understood nor are they always implemented correctly” (Giorgi, 2006, p. 360). However, Giorgi (2006) warns that “if one is going to use a phenomenological method that is based upon the thought of Husserl (1983), . . . then the phenomenological reduction has to be implemented” (p. 355). Giorgi argues that in order to correctly apply phenomenological methods, the researcher must correctly employ phenomenological reduction, meaning the researcher must do the following two things:

Bracket personal past knowledge and all other theoretical knowledge, not based on direct intuition, regardless of its source, so that full attention can be given to the instance of the phenomenon that is currently appearing to his or her consciousness, and . . . the researcher withholding the positing of the existence or reality of the object or state of affairs that he or she is beholding. The researcher takes the object or event to be something that is appearing or presenting itself to him or her but does not make the claim that the object or event really exists in the way that it is appearing. It is seen to be a phenomenon. (p. 355)
In terms of this study, Giorgi’s (2006) quote reminds me to set aside what I know about motivation and competition so that the answers to the research questions come from the participants’ experiences and not from my own.

Giorgi also points out the importance of utilizing imaginative variation or “the refusal to accept the first meaning that emerges from the data until all possible meanings have been explored” (as cited in Beech, 1999, p. 42), as a way to ensure phenomenological reduction. Furthermore, LeVasseur (2003) challenges phenomenological researchers to temporarily break free from the habit of structuring experiences according to how we understand them, producing “a reflective move that cultivates persistent curiosity and allows us to make progress toward the things themselves” (p. 418).

Heeding both Giorgi (2006) and LeVasseur’s (2003) advice, I engaged in reflexivity before the interviews, throughout the interviews, and in the analysis. One way that I engaged in this reflexivity was in the origins of my own interpretations and from where they came along with reflecting on my own experience with key issues of the study.

**Phenomenological Reduction**

Sokolowski (2000) explains, as items or situations become bracketed, they are not forgotten or lost; they are simply frozen in the field (Lewin, 1951). He states that they remain exactly as they were, and we remain exactly as we are. Sokolowski (2000) goes on to say:

> When we move into the phenomenological attitude, we become something like detached observes of the passing scene or like spectators at a game. We become onlookers. We contemplate the world in its human involvement. We are no longer
simply participants in the world we contemplate the involvements we have with the world and with things. (p. 48)

Sokolowski’s quote comes across as a Capra-esque movie plot. Not that phenomenological reduction focuses on the underdog, as is true of so many of Capra’s films. Specifically, however, phenomenological reduction is like the character of George Bailey who is given the opportunity to see his life outside of himself—to witness the things that go on in his life without him affecting his life. Sokolowski (2000) points out that when a researcher “turns on,” or enters this phenomenological attitude, it is said that the researcher has entered phenomenological reduction.

**Researcher’s Role (My Story)**

According to Moustakas (1994), in phenomenological research, the research question should be inspired from a deep personal interest in the problem. Moustakas goes on to say that personal history or a connection with the topic brings about a focus and is essential to the core question of the research. Adding to that, “Payne (2007) . . . argues that reflexivity allows the researcher to acknowledge their role in the reaction of the analytical account. She maintains that one’s theoretical and disciplinary background should be recognized before undertaking data collection to ensure that the research remains open to new ideas” (as cited in King and Horrocks, 2010, p. 127). Upon reflecting on my dissertation topic, there were three aspects of inspiration that lead me to this topic and were bracketed to ensure that they did not cloud my analysis of the research problem.

**Why Projects?**
One of my most vivid memories as a student was in the third grade. I recall my science teacher asking me to read aloud from the text. About two minutes into reading an entry on how fern spores germinate, the teacher stopped me and asked me to stop joking around and to start over from the beginning. Having no idea what she was talking about, I started over at the beginning of the paragraph. Again, a few lines into the reading and she asked me to stop. After being told to stay after class and pleading with her trying to explain that I was not playing around and had no idea why she kept stopping me, I was sent to visit with the principal who asked me to read several lines from a first grade phonics book. After several minutes, the principal called my mother in for a teacher-parent conference. While I was relegated to the hall and not invited into the office, I still recall the conversation involved the words illiterate, slow, and incapable of keeping up. After meeting with eye doctors and a private psychologist, it was determined that I had an unusual learning disorder, caused by gross eye movement which led to developmental dyslexia. Elterman, Abel, Daroff, Osso, and Bornstein (1980) describe the condition in their quote below:

Although some dyslexics display a normal eye-movement reading pattern of repetitive rightward refixational saccades (as the eyes move from the beginning to the end of a line) followed by a large leftward saccade (return sweep) back to the beginning of the next line, most reports have stressed an increased number of fixations, longer pauses between saccades, frequent regressions (leftward saccades on the same line), and abnormalities in the return sweep such as ‘reverse staircase’ (multiple, small, leftward saccades rather than a single, large, return movement). (p. 16)

This eye movement issue meant years of hand-eye coordination therapy and reading tutoring by my mother, who, by good fortune, happened to be trained as a teacher and, by the grace of God, had the patience of a saint.
While the diagnosis of the dyslexia brought with it hours of additional work outside of the classroom, it also brought with it a plan for how to overcome the condition: hand-eye coordination exercises and relearning how to read, with a ruler as a guide, later a finger as a guide, and eventually no guide. All the while, I struggled in school to explain to teachers and other students why it took me five times longer to get done with vocabulary tests, why I had issues with reading comprehension, and why my spelling was atrocious.

By the fifth and sixth grade, I was for all intents and purposes cured. I was reading at an eighth grade level by fifth grade and a high school level by sixth grade. Gone was the stigma of being dyslexic, but what did not go away was my inability to concentrate on lessons in class, how easily my mind wandered from one subject to the next, and how difficult it was for me to finish an assignment. When my doctors discovered my gross eye movement, they ended their search for what was wrong, and in doing so they missed diagnosing my attention deficit disorder. I don’t blame them; in the 1970’s and 1980’s, when I was growing up, children who had Attention Deficit Hyperactive Disorder (ADHD) were ill behaved, incapable of sitting still, and had outbursts. I had none of these telltale signs of hyperactivity. It was not until well into my teens when doctors began to acknowledge ADHD-I (predominantly inattentive).

This undiagnosed disorder may have contributed to my inability to concentrate on such things as teacher-centered lectures, but what it didn’t hamper was my ability to learn from science experiments, social studies projects, geography projects, and other hands on activities. When presented with a project-based lesson, I excelled. If I was asked to create the solar system, I wanted to make sure the planets were in perfect scale and a
representative distance from the sun, even if I didn’t spell all the words right on the poster. As a young student, I was unaware of the hundreds of research studies that talk about self-directed learning or project-based learning. To me, these activities or projects were interesting; they captured my attention and, most importantly, helped me to learn.

**Why Engineering Design Competition?**

During my twelve-year history working in higher education, nine of those years were in Student Affairs. As a professional in student affairs, there were several perspectives that I adopted. First, regardless of my status as a staff member, I was an educator. I took this to heart, not only teaching college success courses in the classroom, but also as a facilitator in workshops and as a low ropes course instructor. Over the years, I realized that I did not have to be in front of a room or on a ropes course to educate; I realized that education could occur anywhere and at any time. My colleagues and I called it seizing a teachable moment.

However, I was quick to realize that teachable moments don’t translate well into department assessments and annual reports. This led me to consider all the different ways in which I was formally teaching or in some way supporting the university’s academic mission. The list was plentiful and full of different programs which I was and am passionate about. Alternative spring breaks, into the street philanthropic programs, leadership retreats, and engineering design competitions were just some of the many educational programs that I was leading or supporting. Around this same time, I started my doctorate program, and, in the second class of the program, I was invited to pick a topic for a mini-research proposal. I chose international service learning projects as my topic and set off, determined to keep the topic throughout the three years of study.
However, my employer and financier of my education announced a fundamental shift in the direction of the university at the beginning of the second year of my doctoral program. This shift toward research and toward a sense of entrepreneurialship led to the university making plans to open an undergraduate research center. It was eventually decided that I would serve as the Executive Director of the new undergraduate research center and transition out of Student Affairs. In light of my new role and responsibilities, I started working even more with the research-based student organizations than I had previously as the Director of Student Activities. What I found was that there was such potential in me being able to assist our students in their self-directed learning by supporting engineering design competitions. Given my former role, my new role, and the university’s transformational shift in focus, I made the decision to move from international service learning to the current topic of engineering design competitions.

Why a Qualitative Epistemology?

A few years back, I had the great fortune to be assigned a reading from H.L. Goodall Jr.’s book *Writing Qualitative Inquiry: Self, Stories, and Academic Life*. At first, I struggled with why we were being asked to read about storytelling. Goodall’s (2008) words had no context, and it had no place in my experience. However, only hours after reading over the assignment, I was on a long drive, and found myself listening to an NPR interview of Adam Hochschild, author of the “War to End all Wars,” a non-fictional narrative about British citizens and soldiers during World War I. His description of how imprisoned British conscious objectors lived was so vivid that I could see the cold breath coming from their mouths. His description of the life of the trench soldiers and their rotting feet brought about by living in cold, wet, muddy conditions was so life-like that I
could smell the stench and hear the squeals of the rats as they moved amongst the wounded and the dead. Hochschild’s description of his book and his reason for wanting to tell the stories and real life experiences resonated with me and provided me an understanding of Goodall’s point. Narrative epistemology goes beyond what Goodall (2008) calls traditional forms of knowledge, “knowing how” and “knowing what” (p. 14), and enters a third realm of knowing described as knowing what it’s like.

The power that comes from this third realm is rooted in the researcher’s motivation. Goodall (2008) describes this motivation as the desire of many writers to want to change things for the better, to inspire, to be life-changing, or to have an impact beyond just the academic world. Goodall suggests this power of change or inspiration is often stifled by most forms of academic writing because it fails to move the reader. Goodall (2008) is careful to acknowledge the importance of the data and findings of other academic writings, but he also goes as far as to say that “we can choose to live larger” (p. 13). In my opinion, there is a true power in finding new ways to communicate knowledge or a new message to a wider public.

However, narrative epistemology is not completely altruistic; I also gain from the stories that I capture and write. For instance, Goodall (2008) shares that “the very act of writing a story, or telling a tale in public or just to a friend . . . alters the way we think about what we know and how we know it” (p. 14). If learning is not enough of a motivation, perhaps being an explorer of new knowledge or providing the world “meaning and value to those sources of knowledge” (Goodall, 2008, pp. 14-15), is the reason I ascribe to the concepts of narrative epistemology.
Reflecting on Goodall’s (2008) book, I realize his most sage advice is his motivation, challenge, and encouragement to those of us inclined to call ourselves narrative epistemologists. Through this advice, Goodall’s (2008) goal is for each of us to add our own stories to collective knowledge. He encourages us to consider the benefits society will gain from these stories but also to consider the benefits that we, as authors, will gain when we discover new knowledge and communicate it through this life changing medium.

**Selection of Participants and Competition Site**

Siegle (2002) and Creswell (2012) defined the role of a gatekeeper as someone who helps a researcher to gain access to the people they wish to study. In terms of this study, a gatekeeper was utilized to determine which engineering design competition teams I should interview. The gatekeeper—the University’s Chair of the Mechanical Engineering Department—offered several suggestions of what he thought would be appropriate competitions. After discussing possible dates and schedules, the decision was made to study the participants of the International Robosub and Roboboat competition teams.

I sought endorsement from the Benedictine University IRB as well as from the Engineering Design Teams’ University’s IRB, as soon as the proposal was approved. I utilized a purposefully selected sample. Creswell (2012) states that purposeful sampling is based on the people and the environments that can best help the researcher understand the central phenomenon under study. Because of the nature of the research problem, the research questions, and my research involving two predetermined teams, the use of a deliberate and purposeful sample was a necessity.
Recruiting Participants

I recruited subjects for the study by sending an email out to all members of both teams. The email explained the purpose of my study and gave clear information on what would be expected of the participants as well as including what they could expect from me as the researcher. The email had a call to action and requested that they respond to me if they were interested in being part of the research study. Those interested were sent an informed consent document which explained precautions that were taken to minimize risks and protect their identities. Finally, students who showed an interest in being part of the study were provided with an email that included a demographic survey and calendar request for face-to-face interviews. The survey included questions that were later used to provide background information about the subjects.

Methods of Data Collection

Creswell (2012) points out that in qualitative research, data should be collected through a process that allows the participants to share their views uninfluenced by the researcher. Creswell suggests that there are a number of ways that data can be categorized and collected including observation, interviews, documents, and audiovisual materials. Creswell goes on to point out that utilizing more than one of these techniques can assist in validating the accuracy of the research findings. Creswell explains this validation technique is a type of triangulation. “Triangulation is the process of corroborating evidence from different individuals (e.g. interviewing both a principal and a student), types of data (e.g. observational field notes and interviews), or methods of data collection (e.g. documents and interviews)” (Creswell, 2012, p. 259). Triangulation of data was used within this study in terms of corroborating evidence from different
methods of data collection. Within this study there were two methods of data collection: interviews and document/artifacts.

**Interviews**

In-depth, semi-structured interviews were conducted in order to explore the life experiences related to motivation for competitors of the International Robosub or Roboboat competitions. After all, Seidman (1991) points out that “interviewing is an interest in understanding the experience of other people and the meaning they make of that experience” (p. 3). To accomplish the study’s purpose, I interviewed eight competitors of the International Robosub and Roboboat teams. This sample size allowed me to deeply delve into their experiences, profoundly reflect on the experiences that participants shared, and lent itself to thick description during the analysis of the interviews. Thick description is defined by Denzin (1989) as having four features:

1. It gives the context of an act; 2. it states the intentions and meanings that organize the action; 3. it traces the evolution and development of the act; 4. it presents the action as a text that can then be interpreted. A *thin description* (italics in original) simply reports facts, independent of intentions or the circumstances that surround an action. (p. 33)

Utilizing Denzin’s (1989) four features allows the researcher to ensure that the reader is getting a deeper look at the experience that the participants are describing. Thick descriptions are also instrumental in making the research more transferable to other situations.

As discussed earlier, there are a number of other possible ways to collect data. However, through face-to-face interviews, I was able to connect with the participants and learn from them directly. Through a face-to-face interview, I gathered data derived from answers to my questions, experiences the participants relayed, and, as Carr and Worth
point out, I was able to “learn from their facial expressions, gestures, and other paraverbal communications that may enrich the meaning of the spoken words” (as cited in Knox & Burkard, 2009, p. 4).

In addition to the initial face-to-face interviews, I chose to gather additional information on the evolution and development of the act of being motivated, as suggested by Denzin (1989). In order to gather these thicker descriptions, all eight participants were contacted and interviewed a second time. During this interview, the participants were asked to describe their childhood and, their early education, why they chose engineering as a major, and what they hoped to do as a future career. Finally, two participants were asked several clarifying questions via email contact.

**Building a rapport with participants.** In order to build an appropriate rapport with the participants, I utilized the advice provided by King and Horrocks (2010). Within their book, *Interviews in Qualitative Research*, they provide a number of concepts that have been shown to set an appropriate tone and environment for research interviews. Utilizing their advice, I first ensured that any emails, letters, and initial face-to-face introductions were friendly but professional. I utilized a proofreader for any correspondence that was sent. In that way, I ensured that each written contact was as professional as possible.

I worked to ensure that the participants knew that I was there as a doctoral student and that I was not there as a university administrator. King and Horrocks (2010) share a story of a student who was interviewing nurses in a hospital. The student shared that the interviews did not seem to be as open and forthcoming as she had hoped. What she came to realize was that the nurses were viewing her as an administrator. Sharing that the
interviews were part of her school work and that she was there as a student, not as an employee of the hospital, along with dressing like a student rather than dressing like an administrator, helped her to build needed rapport. I will utilize the learnings from these researchers by assuring the participants that my interests are academic.

During the face-to-face interviews, I followed King and Horrock’s (2010) advice on interview questions, choosing my words carefully and ensuring that I did not ask leading or overly complex questions, and that I did not use judgmental language. I further considered my non-verbal communication and body language, in the hope of putting my participants at ease, furthering the rapport building, and preventing the opposite effect, making someone uneasy and uncomfortable.

Finally, I employed active listening skills (Brownell, 1986). Active listening skills, asking clarifying questions, and probing for understanding allowed me to balance the need to listen to the responses of the participants, prepare the next question, and reflect on the overall interview at the same time.

**Interview Guide.** In order to create the dissertation interview guide, I followed Weiss’ suggestion of beginning with a “‘substantive frame’ or range of specific topics or issues you are interested in exploring” (as cited in Hesse-Biber & Leavy, 2011, p. 103). Next, I created what Weiss called a “topics to learn about” list (as cited in Hesse-Biber & Leavy, 2011, p. 104). These topics were broad abstract concepts. The authors go on to call each of these “topics” lines of inquiry. According to Hesse-Biber and Leavy (2011), an affective research guide enables the researcher to confirm the following three questions: (a) Is the guide clear and readable?, (b) Does the guide cover all of the topical
areas in which you are interested?, and (c) Are there any topical areas or general
questions missing from the guide? (Hesse-Biber & Leavy, 2011, p. 104).

After my proposal was approved and IRB permission was granted, I pilot tested
my guide in the early stages of interviewing. According to Hesse-Biber and Leavy
(2011), tweaks can and should be made. Continuous improvement is possible, especially
in the semi-structured and low-structured formats.

**Document and Artifact Analysis**

Each of the participants were asked to bring a document or artifact that might
symbolize their experience of motivation. I employed this item in the interviews to
corroborate or expand on their responses to interview questions and elicited additional
responses related to their experiences with motivation. Examples of documents include
“public documents, photographs, audio-visual recordings, journals, artifacts,” (Hahn,
2007, p. 2). Three participants out of eight brought an artifact to their interviews. The
three participant’s artifacts included: (a) a laptop loaded with examples of software
coding that the participant contributed to the design project; (b) a video showing the
successful flight of a quadcopter; and (c) pictures of family members, professors, and
inspiring college staff members. A fourth participant described a crushed Roboboat hull
which was too cumbersome to bring to the interview. However, after the interview I was
able to visit the lab and see the artifact that he had described. These unique artifacts
allowed me to again use thick descriptions, multiple data sources for triangulation of the
data in my analysis.

**Capturing the data in field notes**
Bogdan and Biklen (2003) provide advice on what should be included in field notes. Utilizing this advice, my notes included descriptive summaries of what happened in each interview. These descriptive notes are defined by Bogdan and Biklen (2003) as “the researcher’s best effort to objectively record the details of what occurred in the field” (p. 112). My field notes included relevant portraits of the subject, description of the environment, relevant activities that occurred, observed behavior, and descriptions of the activities that were observed.

**Data Analysis Method**

Typically in the phenomenological method, an interview is utilized as a means of collecting data and then it is analyzed utilizing a variety of optional methods. Examples of methods include the Stevick-Colaizzi-Keen Method (Stevick, 1971; Colaizzi, 1973; Keen, 1975), Giorgi’s method (1979), and others. However after considering multiple methods, the one that I have had success with in the past in other interview scenarios is the van Kaam method. The method outlined by Moustakas provided me with a data analysis method that is both tested and recommended by both Moustakas (1994) and Creswell (2007). van Kaam’s method is:

Using the complete transcription of each research participant:

1. *Listing and Preliminary Grouping*
   List every expression relevant to the experience (Horizontalization).

2. *Reduction and Elimination:* To determine the Invariant Constituents:
   Test each expression for two requirements:
   a. Does it contain a moment of the experience that is a necessary and sufficient constituent for understanding it?
   b. Is it possible to abstract and label it? If so, it is a horizon of the experience. Expressions not meeting the above requirements are eliminated. Overlapping, repetitive, and vague expressions are also eliminated or presented in more exact descriptive terms. The horizons that remain are the invariant constituents of the experience.
3. Clustering and Thematizing the Invariant Constituents:
Cluster the invariant constituents of the experience that are related into a thematic label. The clustered and labeled constituents are the core themes of the experience.

4. Final Identification of the Invariant Constituents and Themes by Application:
   Validation
   Check the invariant constituents and their accompanying theme against the complete record of the research participant: (1) Are they expressed explicitly in the complete transcript? (2) Are they compatible if not explicitly expressed? (3) If they are not explicit or compatible, they are not relevant to the co-researcher’s experience and should be deleted.

5. Using the relevant validated invariant constituents and themes, construct for each co-researcher an Individual Textural Description of the experience. Include verbatim examples for the transcribed interview.

6. Construct for each co-researcher an Individual Structural Description of the experience based on the Individual Textural Description and Imaginative Variation.

7. Construct for each research participant a Textural-Structural Description of the meanings and essence of the experience, incorporating the invariant constituents and themes. (as cited in Moustakas, 1994, pp. 120-121)

Within the van Kaam method outlined in the preceding list are three concepts that must be understood in order to appropriately analyze the co-researchers stories. The concepts include (a) horizonalization, (b) imaginative variation, and (c)textural and composite structural descriptions, which will be discussed next.

**Horizontalization**

Within van Kaam’s method (1959, 1966) is a term called a horizon. Within the quoted methodology, van Kaam (1959, 1966) explains that the horizon is every expression relevant to the experience. There are several additional terms that are important to understand about a horizon. First, every applicable horizon, invariant horizon (Moustakas, 1994), or invariant constituent (van Kaam, 1959, 1966) starts out as
a suspicion. That means that an invariant horizon or constituent may seem to have some sort of unique quality that stands out to the researcher. Several things can come of this suspicion: it could turn out to be a major theme and one that goes further down the steps of analysis, it could turn out to be a minor point that gets elevated to a part of an overall theme, or it could eventually prove to be a red herring that has no bearing on the co-researchers’ experience.

Moustaka (1994) explains that horizonalization is the act of temporarily setting aside these suspicions and allowing all horizons to be held at equal weight. Moustakas (1994) explains that this is a willingness on the part of researchers to be receptive to all statements by the co-researcher. He goes on to share that horizonalization requires that the researcher take every horizon statement at the same value and give them each equal weight. By focusing on each statement equally and allowing the co-researcher the opportunity to make the statement, the researcher does not inadvertently move on to a different subject that seems more interesting to the researcher, and by doing so, inadvertently end an important point that the co-researcher was attempting to make.

**Imaginative Variation**

Giorgi (2006) explains that the role of imaginative variation is to assist in the discovery of essential characteristics of the phenomenon being considered. Kockelmans (1967) helps to explain imaginative variation by starting with reduction. If reduction takes us back to the very essence of the nomoea, the very facts of the subject, then the use of imaginative variation asks us to look at that essence in a way that would allow us to find a characteristic that is true for all other examples of that subject. Kockelman
discusses the color red and states that there are many different shades of red, but in every shade of red there is an essence of redness.

Moustakas (1994) provides the following steps to completing imaginative variations, which include:

1. Systematic varying of the possible structural meanings that underline the textural meanings;
2. Recognizing the underlying themes or contexts that account for the emergence of the phenomenon;
3. Considering the universal themes or contexts that account for the emergence of the phenomenon, such as the structure of time, space, bodily concerns, materiality, causality, relation to self, or relation to other;
4. Searching for exemplifications that vividly illustrate the invariant structural themes and facilitate the development of a structural description of the phenomenon. (p. 99)

By using Moustakas’ (1994) four points to achieve imaginative variation, I was able to look at my participants’ experiences with a fresh perspective while also seeing patterns that emerged from their descriptions.

**Textural Individual and Composite Structural Descriptions**

van Kaam’s method includes three steps where the textural individual descriptions or composite structural descriptions are mentioned. Moustakas (1994) provides examples of a textural individual description can be seen in such studies as Copen’s 1993 study on insomnia where he combines a person’s life experience with insomnia into horizons, then into major themes, and then into textural descriptions.

Copen’s example of a textural individual description follows, “The experience of insomnia for Jim is one of restless fluctuation from an initial falling asleep to a sudden awakening. Wanting desperately to sleep but to no avail, he is ‘propelled’ to be awake” (as cited in Moustakas, 1994, p. 133). The narrative continues in the example, but the
point is made. There are many purposes of the individual narrative. First, it can be used to revisit with the co-researchers to see that the textual descriptions are representative of their experience. Second, it can be used as examples and provide thick description for the data analysis chapter of the dissertation to illustrate the life experience of the individual.

Similarly, van Kaam’s method also calls for a textual composite description to be created again using thick descriptions. To complete this step, all individual descriptions are synthesized into one large composite structural descriptor, which gives any reader a sense of the combined lived experience of the co-researchers. In the case of this dissertation, the experience is the lived experience of motivation by the engineering design competitors.

**Ethical Issues**

Creswell (2012) provides a number of situations that a qualitative researcher must consider when undertaking a study. Those ethical concerns that most directly affected this study include ethical reporting and treatment of the co-researcher.

**Ethical Reporting**

Hesse-Biber and Leavy (2011) warn of the importance of listening without being critical, without judgment, and without interruption. Following the transcendental principles of epoche, reduction, and, especially, horizontalization allows for placement of every horizon on the same level. When followed correctly, this prevented for Hesse-Biber and Leavy’s (2011) concern. Creswell (2012) warns against falsifying information or making the findings fit a script that you are hoping to achieve. With the usage of
individual textural structural descriptions, the chances of falsifying information are nearly eliminated.

**Treatment of Co-Researchers**

Robson (2002) warns of additional ways that a researcher can cause ethical dilemmas, including withholding information about the purpose or facts of the research, placing people into the research or experiment without their knowledge or permission, and coercing people to participate. In this study, an informed consent was used to combat these possibilities. According to Cohen, Manion, and Morrison (2008), there is a list of factors that the researcher must explain to participants which include:

- the purposes, contents and procedures of the research
- any foreseeable risks and negative outcomes
- discomfort or consequences and how they will be handled
- benefits that might derive from the research
- incentives to participate and rewards from participating
- right to voluntary non-participation, withdrawal and rejoining the project
- rights and obligations to confidentiality and non-disclosure of the research, participants, and outcomes
- disclosure of any alternative procedures that may be advantageous
- opportunities for participants to ask questions about any aspect of the research
- signed contracts for participation and establish their own ethical position with respect to their proposed research (p. 55).

Each of these factors were utilized and explained during the interview and data collection.

In addition, Cohen et al. (2008) also describe several other ethical concerns, including privacy and anonymity. In order to ensure that privacy and anonymity were achieved, no mention of the University was utilized and pseudonyms were used in the
interview, transcripts, and in the final dissertation. Copies of the taped interviews were erased once the transcripts were checked for accuracy. In the interim, the tapes were kept under lock and key in my private office.

**Strategies for Validating Findings**

Creswell and Miller (2000) point out that there are a number of procedures in which researchers can validate their findings. In order to determine the appropriate procedures, I looked to Creswell and Miller who provided several aspects that should be considered. Key among these aspects is whether the researcher is using a qualitative or quantitative paradigm or lens for the study. Creswell and Miller suggest that those researchers using a quantitative lens will want to validate their scores, instruments, and their research designs. Those researchers using a qualitative paradigm, on the other hand, will have “a lens established using the views of people who conduct, participate in, or read and review a study” (Creswell & Miller, 2000, p. 125). Golafshani (2003) provides a number of thoughts about validating findings in the following account:

> While the credibility in quantitative research depends on instrument construction, in qualitative research, ‘the researcher is the instrument’ (Patton, 2001, p. 14). Thus, it seems when quantitative researchers speak of research validity and reliability, they are usually referring to a research that is credible while the credibility of a qualitative research depends on the ability and effort of the researcher. Although reliability and validity are treated separately in quantitative studies, these terms are not viewed separately in qualitative research. Instead, terminology that encompasses both, such as credibility, transferability, and trustworthiness is used. (Golafshani, 2003, p. 603)

In Golafshani’s (2003) quote, he communicates the difference in reliability and validity between qualitative and quantitative research. Because this study is qualitative in nature, Golafshani’s advice on qualitative research was utilized.

**Trustworthiness**
Krefting (1991) suggests that, in order for a qualitative study to have worth, trustworthiness must be established. She goes on to share that trustworthiness must permeate the study, including in the study design stage, during data collection, and in the interpretation phase. Krefting recommends Guba’s (1981) four-part model for establishing trustworthiness. Guba’s strategies include: (a) credibility, (b) transferability, (c) dependability, and (d) conformability.

**Credibility.** Shenton (2004), quoting Lincoln and Guba (1985), insists that establishing credibility is one of the most important elements in ensuring trustworthiness. Shenton suggests that, in order to establish credibility, researchers must adopt qualitative methods which have been successfully used in previous studies of a similar nature. Westbrook (1994), also quoting Lincoln and Guba (1985), suggests three techniques for ensuring credibility including the following: (a) prolonged engagement, (b) persistent observation, and (c) triangulation. Utilizing these three concepts ensures that the researcher is able to identify what Leininger called “recurrent features such as patterns, themes, and values” (as cited in Krefting, 1991, p. 217). As the patterns, themes, and values continue to reoccur, credibility is established. For this study, triangulation was used for establishing credibility.

**Transferability.** While generalization is a key concept for external validity in quantitative research, applicability, fittingness, or transferability, is the criterion against which qualitative research is judged (Krefting, 1991). Krefting suggests that qualitative research achieves transferability when the findings fit into contexts outside the study situation. However, Lincoln and Guba maintain the following points:
Transferability is more the responsibility of the person wanting to transfer the findings to another situation or population than that of the researcher of the original study. They argued that as long as the original researcher presents sufficient descriptive data to allow comparison, he or she has addressed the problem of applicability. (as cited in Krefting, 1991, p. 216)

In order to ensure that sufficient descriptive data were provided, strategies such as thick descriptions and field notes were utilized.

Thick description, as mentioned throughout the methods section, was employed in the textual individual and composite structural descriptions, field notes, and as a tool for considering new questions between interviews. Utilizing thick descriptions helped to validate the findings because it delved into the meaning, the root, and the context of the phenomenon rather than relying on a thin description. Denzin (1989) describes this as descriptions which “simply reports facts, independent of intentions or the circumstances that surround an action” (p. 33). Leaving out the intentions and circumstances would have diminished the analysis and prevented the conclusions from being as effective as possible.

Dependability. In order to achieve dependability or what Krefting (1991), quoting Guba (1981) calls “auditable,” other researchers must be able to understand the process used to conduct the research and analyze the data. One procedure that Krefting suggests in order to establish dependability is utilizing triangulation within the study’s methodology. Krefting proposes that triangulation ensures “that the weaknesses of one method of data collection are compensated by the use of alternative data-gathering methods” (p. 221). Triangulation also provided a deeper opportunity for reflection and consideration of thick descriptions. This was achieved by providing additional data for me to ponder and consider in my analysis. By including three data methodologies, this
study more effectively explored the lived experience of the subjects. In this study, evidence was corroborated between interviews, document/artifact analysis, and field notes.

According to Krefting, having “methodological experts . . . check the research plan and implementation is another means of ensuring dependability” (p. 221). This methodological check of the research plan and implementation is built into the iterative process of any well advised dissertation and institutional review process, my own included.

**Conformability.** Conformability is defined by Bradley (1993) as “the extent to which the characteristics of the data, as posited by the researcher, can be confirmed by others who read or review the research results” (p. 437). In order to determine if the data, findings, and conclusions were confirmable, member-checking was utilized. According to Creswell (2012), member-checking is a strategy in which participants will be asked to review their transcripts for accuracy and completeness. All eight participants were provided copies of their transcripts and returned them with minor or no changes.

**Field Notes**

A final validating strategy that was used was the aforementioned log and field notes. Utilizing these field notes enhanced the validation of the findings by immediately capturing the experiences, thick descriptions, and nonverbal signals of the participants. While some notes were captured during the interviews, a majority of the notes were taken immediately following the interview. Also included in the field notes were reflexive notes that were appropriate. Bogdan and Biklen (2003) suggest that the field notes are a great place to add any thoughts, hunches, ideas, and suggestions for the next interview.
They also describe the reflexive notes as a time to confess any mistakes, shortcomings, or prejudices.

**Summary**

To summarize the purpose of this dissertation is to describe the shared experience of motivation for competitors of International Robosub and Roboboat competitions from a selective engineering university and to provide educators with a better understanding of how to use engineering competitions in a way that will motivate their students to learn the design process. In order to accomplish this purpose, a phenomenological study, using in-depth interviews and document/artifact analysis was conducted. The framework for the methodology is social constructivism.

After investigating each of the qualitative methods, conversing with several faculty members, and after a review of several other dissertations that utilize similar methodology, it became clear that my research problem, by virtue of the research question, was best suited for phenomenology. Utilizing the knowledge of Giorgi, Moustakas, Sokolowski, van Manen and Schutz, I adopted the experiential phenomenology viewpoint while being true to the essential transcendental requirements of Husserl (1931), in terms of noema, noesis, epoché, bracketing, and phenomenological reduction. I determined that Moustakas’ methodology (2004) would be most appropriate as my data collection method. After studying several options for how to best analyze the results of my research interviews, I determined that the van Kaam method (1959, 1966) was the most appropriate procedure. As I began the process of interpreting my research, I kept in mind the importance of horizontalization, imaginative variation,
thick descriptions, and textural descriptions within van Kaam’s methodology (1959, 1966). Through each of these steps, I utilized reflexivity and a sense of ethical responsibility. Utilizing these methodologies, I am certain that I was able to serve as a conduit for sharing my co-researchers’ experiences with motivation.
CHAPTER 4
Participant Profiles

“I think the big mistake in schools is trying to teach children anything, and by using fear as the basic motivation. Fear of getting failing grades, fear of not staying with your class, etc. Interest can produce learning on a scale compared to fear as a nuclear explosion to a firecracker.”

~ Stanley Kubrick

In order to tell the stories of motivation for a set of Roboboat and Robosub competitors, I interviewed eight male students who ranged in educational progress from their freshmen year to graduate studies. Three participants were graduate students earning their master’s degrees in mechanical engineering. One participant is earning his master’s in software engineering. Two participants are working on their bachelor’s degrees in aerospace engineering; one participant is earning his bachelor’s in mechanical engineering, and one participant is earning his bachelor’s in computer engineering. All eight participants or 100% are full-time students. Each student is majoring in engineering and competed in a recent Roboboat and/or Robosub competition. Seven of the participants are between the ages of 18-29; one is between 30-39.

Several of the participants spoke of their family’s support as a context for motivation, which might not be surprising when one considers that each of the student participants were second or more generation students. Two participants or 25% stated their father was the immediate family member to graduate from college. The same amount of participants listed their mother as the family member who graduated from college. Three participants are from homes where both parents graduated from college, and one participant has both parents and at least one sibling who are college graduates. Only one student did not begin their undergraduate or graduate program
studies at the institution and was a transfer student, and that same participant was also the only veteran among the two teams.

While the diversity of the participants goes beyond race, there are a number of ethnic backgrounds represented by the Robosub and Roboboat teams. Five participants are Caucasian; one participant is Asian; one participant is African American; one participant is multi-racial, of both Caucasian and Hispanic backgrounds. Seven of the participants described themselves as single, and one participant described himself as living with a partner.

In terms of experience with Engineering Design Competitions, there was only one participant whose Engineering Design Competition experience was limited to the Robosub or Roboboat competition. The largest number of Engineering Design Competitions by any one participant was 20 competitions. The median number of competitions was five. Tables, which provide participant demographic information, can be found in Appendix D.

As one might expect, their individual stories paralleled many of the theories and concepts of both motivational theorists and experiential learning researchers. Each of these young men were from very different backgrounds, and yet they had strikingly similar learning styles, reasons for being motivated, and equally comparable reasons for being disinterested, bored, and demotivated in certain educational situations. Moreover, it was clear that no one had ever asked these students about their motivation to learn. Yet, each easily recalled specific examples of, and were not shy in naming, both engaged and unengaged professors and shared situations and pedagogies they considered both ideal and those that missed the mark. In adding these profiles, which highlight both
the teams and the individuals, I will provide readers with an understanding of my co-researchers’ perceptions and experiences with learning motivation and being part of their engineering design team. Within these profiles, the reader will find both demographic and personal information about each of the participants and will be provided context and allow for a possibility of transferability of the data. Without these profiles, the reader could not fully comprehend the team member’s stories. While the individual quotes stand on their own in informing readers about learning motivation, they cannot provide a full sense of who each of these amazing students, teammates, and future engineers truly are.

**Team Profiles**

This section provides an explanation of the experiences that each of the teams encountered in the competition. Fundamentally, all Robosub and Roboboat teams have similar experiences. Each team travels with their boat or sub from their home institution to the competition site. In the case of Robosub, the teams traveled to the Space and Naval Warfare Center in San Diego California, while Roboboat was hosted at the Founders Inn and Spa, Virginia Beach, VA. While Roboboat and Robosub are different in the challenges that the teams face, the format of the two competitions is similar. Each competition lasts between five and six days. Within those days, groups are able to practice on the competition field. Teams from both competitions are able to determine what about their design is working and what is not. They have several days to determine how to fix the issues with their robots. Arguably, the main part of any design competition is the months of work and learning that occurs before the competition. At the competition though, the challenge courses are the main event. In addition to the
challenge courses, both the Roboboat and Robosub teams must write a journal-worthy “white paper” about the engineering that they used to accomplish the challenge course tasks. Further, the teams lead a presentation for a panel of judges who assess the learning that has occurred before and during the competitions.

**Roboboat Team Challenges**

For this Roboboat team, the competition was divided into three parts. The three parts of the competition were used as demonstrative assessments of what each team had learned. Each part of the competition assessed a specific engineering design element, as well as the Roboboat’s structural integrity. Figure 6 shows the layout of the different tasks within each of the three parts of the competition.

![Figure 6. Roboboat Challenge Stations. From the 6th RoboBoat Competition - Final Rules (p. 4), by Association for Unmanned Vehicle Systems International, Arlington.](image-url)
The first section was the only mandatory piece of the competition and consisted of a propulsion test, which measured the strength of the boat, navigation through a starting gate that measured control, and passing through a set of speed gates to show speed. The second section consisted of a navigation channel which required the autonomous boats to navigate through a channel of buoys, staying between red buoys on one side and green buoys on the other while avoiding stray yellow buoys anchored throughout the channel. The second portion of the competition was optional and served as a score multiplier, meaning that any points received in the third section of the competition would be multiplied if the team attempted and completed all or parts of the navigation channel.

The final section of the competition included six challenges. The first challenge was called “catch the ball” which required the boat to dock and then deploy a secondary autonomous vehicle. The secondary vehicle needed to retrieve a Velcro® covered hockey puck, and return the hockey puck back to the Roboboat. The second challenge, named “Sneaky Sprinkler,” required the Roboboat to push a red e-stop button that set off a sprinkler system. However, there were two red e-stop buttons, and only one would operate the sprinkler. In order to determine which e-stop to press, the Roboboat had to visually determine the location of a submerged white buoy, which was located under the correct e-stop. The third challenge station was called “Rock, Paper, Scissors, Lizard, Spock.” For this challenge, there were five target signs protruding from the water. Each target was marked with symbols depicting a rock, paper, scissors, a lizard, or Spock. In order to score points for this challenge station, the Roboboat was required to determine which of the five targets had been heated 20 degrees warmer than the other ones. Then,
the roboboat had to communicate with the judges’ tent on shore, providing the name of a symbol that would beat the one that was warmer as well as the GPS position of the warm target. The fourth challenge was a game of capture the flag with a small, radio-controlled boat driving circles in the middle of the lake. In order to complete this challenge, the roboboat was required to find the purple boat in the water, engage with the boat and capture the flag which was attached to the radio controlled speed boat. The fifth challenge was “Shoot through the hoop.” To complete this challenge, the Roboboat had to locate three hoops along the shore. Once located, the Roboboat had six attempts to shoot missiles or arrows through the hoop to score points. The final challenge was reversing course and returning back through the navigation channel and autonomously returning to the starting docking station.

**Roboboat Team Results**

While no team was able to complete every challenge station, the Roboboat team that participated in this research study was able to complete a number of the tasks and did come in one of the top three positions for the year that they competed. While participants did acknowledge placing in the top three was an honor, multiple participants pointed out that they could have won first place. Darian, one of the team members, shared why he believed that the team did not win first overall. He shared that there was not enough manpower, stating that there were not enough people working on either the mechanics or the software. Darian also identified a number of mechanical issues that kept the team out of first place, stating:

The software portion was hard, and there was only one student doing everything by himself. And, there were times that there were errors in the code, and we
would fix things but . . . then, he would forget to go back and reverse those things.

So, we had software issues, and one of the biggest issues we had . . .
 mechanically, was the thrusters. Originally, when we had purchased the thrusters they were about $200. Now, they are up to $900 [for] each thruster. And the first day, we burnt out a thruster. So that situation was a huge problem. And then, uh, you know, once again going back to my motivation of learning and someone else's motivation, people want to build these extravagant systems, uh at these competitions, but my thing is, ‘Take what . . . you’ve done in the past year. If it's worked, keep it the same. If it hasn’t worked, change it.’

In a written correspondence with Chad after his interview, he shared that the team
found difficulty in the navigation of the roboboat, but found success with the “Shoot
through the hoop” and “Rock, Paper, Scissors, Lizard, Spock” station.

At the Roboboat competition, we came with a mechanically robust boat but some
software was not fully tested. Each portion of the competition was tested under
lab conditions but not fully integrated into the main code. The hoop station was
very strong along with the rock, paper, scissor station but the navigation and
switching between these tasks was the untested portion of the code. This is where
we had the largest problem; we had identified this as a problem after the first set
of test runs along with a thruster failure. As the thruster failure was getting fixed,
the control algorithms were rewritten in a more conventional left/right differential
thrust configuration. This was a change from the thrust and yaw angle the system
was originally written for. This cost us about two days of completion’s testing
time but ultimately provided a more familiar controller type that was easy to
interpret. This allowed us to complete the integration of the machine between the
stations and navigation.

**Robosub Team Challenges**

The Robosub competition consisted of six independent underwater tasks,
including: (a) docking with buoys; (b) passing over an obstacle; (c) manipulating a
steering wheel and shifter; (d) dropping markers at a target; (e) firing torpedoes through a
cutout goal; and (f) grabbing and releasing an object. Often, the competition will include
some sort of theme. In 2013, the theme was “licensed to drive” and each of the tasks was
themed around driving. The grabbing releasing challenge was themed as if the sub was
delivering a pizza and the firing of torpedoes was designed to look like the sub was throwing change into a toll booth. Figure 7 provides a visual context to the environment of the competition.

Figure 7. General layout of the Robosub Arena. Adapted from Official Rules and Mission AUVSI & ONR’s 16th Annual RoboSub Competition (p. 16), by Association for Unmanned Vehicle Systems International, Arlington.

Robosub Team Results

During the competition, the team was unable to get their untested visual system to work, having issues with lighting conditions. However, the team was able to switch strategies and qualify for the finals using a timed motor command. While the team competed in the finals, they did not rank in one of the top eight published places, instead, finishing somewhere below tenth place. The team did, however, win a prize for outreach.
for the year-round work they had done to promote robotics within their community’s middle schools.

For the individual team members, Robosub was not just a challenge of how to beat the competition or how to get the sub to steer appropriately. Like many work teams, the Robosub team had to navigate through the difficulties of group dynamics. Connor shared the story of picking up the pieces after the former team leader dropped off the team, stating:

Robosub, that was particularly interesting because the couple of weeks before the competition . . . the person who had been leading the project, just, was like, “Yeah, I don’t . . . I’m not really interested anymore.” He lost his motivation. So, he just wasn’t gonna go to competition. There was no one on the team that really knew all of the systems, no one that really knew how everything worked. So that, I think, really motivated the team, uh, to pick things up and, you know . . . Because at that point, there’s no one in charge, there’s no one leading the development effort. People had to pick things up and learn with it. Um, so people had to learn things very quickly, and they did a pretty good job.

So I think that was probably the most meaningful thing that happened, was by losing the project leader, everyone else was like, “Well, we’ve got to do something,” you know, “We’re not gonna just show up to this competition, and not do anything,”

Within Connor’s quote are signs of a team that never seemed to become interdependent on each other, as described by Campion et al. (1993). In addition, there were distinct signs of a group that never moved into the performing stage. With a lack of interdependence and no work being done in a timely manner, the former leader gave up his membership and left the rest of the team to recover.

Chad shared his doubts that they would be able to recover when the leadership abandoned the competition.

At Robosub, I was not confident that the robot would perform past basic timed thruster movement. The robot had an inertial navigation algorithm written a couple weeks before, but it was largely untested. We spent all testing time trying
to get that to function, unsuccessfully. We tried using a vision algorithm but due to changing lighting conditions it was unsuccessful at picking up the buoys. I felt lucky we were able to qualify with timed motor commands.

Connor described a lack of motivation for the competition.

We didn’t do very well at Robosub . . . We were not motivated to do really well. We were motivated to go there, and not look like idiots, but we didn’t . . . we weren’t as excited about Robosub, because we didn’t feel like . . . we had the ownership of it.

Within Connor’s statement is the concept of what Nicholls (1984) described as ego involvement in motivation. As Connor and others point out, they could not lose face; they could not let their ego be compromised.

But even with this lack of motivation to win, Lewis described seeing the competition as a sense of motivation which built around getting better and not having these same issue and feelings in the years to come.

I don’t know if there’s anything that’s diminished motivation to learn about the Robosub. When we got there we knew our sub was not at the level of other peoples’ subs but that was . . . it wasn’t really demotivational or let’s give up, which was kind of our plan when we got there because we knew we couldn’t compete but it was more of for . . . next year we’re going to do better.

**Individual Profiles**

Within this section, individual profiles of each of the eight students that participated in this study are presented. The goal of this section is to provide a clearer picture of the co-researchers while giving a context to their voice and their stories of learning motivation. While providing a platform for their voice and their story is an essential goal, so too was the desire to protect the participant’s anonymity. In order to protect each participant’s identity, pseudonyms have been used throughout the
dissertation. Within each of the profiles, the following four questions are considered: 1) How do these student contestants describe their motivation and ascribe meaning to it personally; 2) In what context does motivation occur to them, both individually and in interaction with others; 3) Who helped bring about motivation for these student contestants; and 4) In what ways does this motivation propel them to act, learn, or achieve?

Adam

Adam, a 19 year old sophomore, was a freshman at the time of his Robosub experience. He is a Caucasian male who lives with his partner while studying full time to earn his bachelor of science in aeronautical engineering. Adam is a second generation college student whose father graduated from college. Adam started the conversation a bit apprehensive; he had been recruited by his teammates instead of directly by me. After explaining my research and the type of questions I would ask and sharing what I would do to keep his anonymity, he seemed more comfortable.

Adam grew up in what he described as a lower middle class community on the eastern seaboard of the United States. His parents worked hard to provide for their family, which required Adam to spend long stretches of time by himself while his parents worked evenings and weekends. Adam revealed that the neighborhood in which he grew up was only two miles from an area of town where people were regularly involved in violent shootings. He shared that, while he felt safe, people were often killed only miles from his home. He also shared that he had to spend quite a bit of time home alone in this neighborhood:
I grew up in a lower middle class community. My parents have always worked late, so in elementary and middle school, I would attend an afterschool program. On weekends and during the summer I would spend most of my time alone at home.

While Adam was in elementary school, his parents determined that the school he was attending did not offer him an appropriate education and that he was not likely to find a better school within the school district that they were living. Adam expressed it this way:

My parents didn't like the schools in the area so they had me go to a school in a different district that was about half an hour away. Just before middle school, we moved to a much nicer house that was part of the district of the school I had been attending.

His mom, a civil servant, and his dad, a small business owner, saved for years to pay for the current family home. Adam described his living arrangements as:

My parents have always worked really hard for what we have. My mom works at the post office, and my dad owns a small business. They make about the same money. When people see our house they think we're rich, but really it's just a couple decades of saving money.

In high school, Adam was involved in the International Baccalaureate program, the math team, and MATEROV team, which is a robotics competition very similar in nature to the International Robosub team.

According to Adam, he has always had a very strong relationship with his parents, stating that they have never had to be very restrictive with him, but that as long as he can remember they have put a large emphasis on his grades:

My parents would get really mad if they felt that [I underperformed] . . . because I didn't try my hardest. I've always been in the hardest classes and usually getting mostly A’s and B’s, so there weren't that many problems.
In middle school, Adam took a standardized test that said that he had an aptitude for math, science, and engineering, among the choices of possible jobs was aeronautical engineering. He confessed that the job sounded fun, and he has been on that same path ever since. Adam shared that his life goal has always been to try to do impressive things. While he has not chosen a final career focus, he does know that he wants to work in engineering in the space industry. Also on his agenda is to attaining a master’s degree, getting a job, and getting married.

In college, Adam is a member of the Honors Program, the Honor’s Student Association, Astronomy Club, and competes on the Robosub team. Within the Robosub team, Adam served as a mechanic specialist. A great deal of Adam’s beliefs about motivation to learn were derived from his opinion on what could have been done differently in the area of the mechanics of the Robosub; he intends to come back next year to help the team improve in this area.

Robosub was Adam’s first engineering design competition. However, Adam reflected that he prefers to learn in a project-based setting and stated that projects keep him more engaged. Adam also sees that project-based learning is more purposeful than completing homework questions. He believes that solving research problems is less contextual. According to Adam, they are either right or wrong, and then you move on. With a project, if you are wrong, there are consequences. One must then ascertain why. As Adam stated:

I’m just more involved and so . . . when [you] do a problem, it ends when you get the right answer, or you get the wrong answer and you just give up. But with the project, even if you eventually give up, you still have to put more time and you can see your progress in it, which is more important than just a yes or a no. It feels like something bigger than just a question.
In addition, he also reflected on the type of environment that made him feel less engaged or the type of method of learning that provided him the least incentive to learn:

Really, the only things that demotivate are just really long lectures because, uh, at that point, it just feels like it would be more worth it to just look at the book afterwards. There’s a couple of classes where they seem like they’d go on forever. Um, there are parts of it . . . I feel like I can get something out of it but a lot of it just goes on and on and on. Sometimes, I had classes where there’s like merely a graph of the situation as like Math or like solids or something. Some of the concepts are kind of simple . . . like metals or something . . . when you just talk about . . . metal. If you pulled on it this hard and it would stretch by this length, but it’s like, ‘Oh, that’s not very interesting and should not last for an hour.’ It makes you fall asleep a couple of times even if your eyes are awake and are open.

When asked to describe how the Robosub competition differed from his experience with long lectures and what keeps the competition engaging, he shared:

I’ve done some programming in it. So . . . from there it’s like the next step beyond just programming on a computer to seeing the actual . . . movements and influences can have on a machine, like visual processing, and seeing that it can be guided by that. It’s a lot more real . . . because as much as you like [to] program . . . it is like riddle processing. You can’t tell if it really works unless you put on something that’s moving and using it.

While Adam felt that there were large areas of improvement needed in the Robosub competition, he also saw lots of learning. In reflecting on what he was able to learn during this competition, Adam shared the following about the importance of testing each subsystem and the system as a whole:

Some of the biggest thing are . . . just from being there, um, [I] really got to see how the competition works . . . How much goes into actual engineering because . . . you could have a fantastic sub but if you never test it, then you’re not going to go anywhere with it unless you’re really, really lucky . . . You need to do a lot of it . . . We never like got to test with it earlier and I never got like two or three tests in and they’re, they’re really basic tests. Like we really can’t test too much.

For Adam, the motivation that occurred around his experience with Robosub was not one of wanting to win. Adam knew coming into the competition that the Robosub
was not of winning caliber. Adam wanted to save face. He wanted to ensure that he and his team did not look like failures and went on to say:

If you do really poorly, which is how it was this time, then you feel bad about it, but . . . you really want to learn more so you can make it so that never happens again.

While Adam was by far the most critical of his time on the team, often referring to other college teams as much better than his, he still shared that he learned a number of important lessons and that he would return for another year. “I would definitely go back to it and try it again, just kind of a better outcome and do much, much better,” he said.

Adam seems to have gained his parents’ work ethic and has applied it to being the best student and best engineering design competitor he can be. Adam is driven by deadlines and focused on being the best. Adam did not sugarcoat his disappointment in the effort that his teammates displayed, but he also is willing to learn from failure and come back with a goal of improvement.

Chad

Chad, a 21 year old senior studying mechanical engineering, describes himself as multi-cultural, sharing that he is of Caucasian and Latin backgrounds. He is a second-generation student; his father graduated from college. Chad was dressed in a fraternity jersey and jeans and was carrying his computer, which was covered with stickers of his favorite bands, peace signs, a Human Rights Campaign equality sign, and a recycle symbol.

Chad’s childhood had phases of structure and intensity coupled with times of being unsettled and chaotic. He recalls his earliest years with his family as both supportive and strict. His father was very intense while his mother was a free spirit:
I grew up with a supportive family with my father being a structured, education-intensive influence while my mother was a self-described free spirit and was very artistic. My younger brother and I grew up with a Filipino nanny. While our parents were working, we would spend many nights with our nanny’s family. My dad was strict and would . . . keep the family from eating until all our homework was complete and he had checked it. My mother was strict but put less emphasis on education and really was less involved with my brother and me as a whole. We have been allowed to pursue our own interests. I spent a lot of time away from home and involved in external activities.

By the time he was eight, Chad’s parents had divorced, and both his parents turned to alcohol to deal with their depression and anger. Chad and his brother were moved from parent to parent until the fourth grade when they moved in with their aunt and uncle while their parents sought help for alcohol addiction. He reflected on this story in this way:

My parents got divorced when I was eight and that put financial stress on both sides. This and the custody battle pushed both of my parents into alcohol abuse. In the 4th grade my brother and I moved in with my aunt and uncle until both of them were more stable. My education was put first and all of my family has been supportive of my brother and I allowing me to end up doing what I am passionate about.

Regardless of with whom he and his brother lived, their schooling was a constant and stable environment. Chad was a fan of the education he received and the teachers at his school but did not appreciate what he considered to be a forced religious education.

He explained:

I went to Catholic school until 8th grade and then a magnet school specializing in technology. I didn’t like having the same families in my classes from K through 8 or the religious ideas that the Catholic school taught, but the teachers were great and inspiring. In high school, I was offered great opportunities in everything from auto shop to cinematography classes.

It was at his magnet school where Chad was introduced to robotics competitions, which coupled with his love for creativity in both the arts and mechanics, led him to
pursue engineering. During our conversation, Chad shared that he dreams of working in the world of robotics as a career:

My dream is to have a job that I am passionate about in the unmanned systems world that allows me to pursue my other interests such as restoring classic cars and working with film.

Chad’s role on the Roboboat team was to act as pilot in command of the team’s subsystem vehicle. As the pilot of the subsystem, he ensured the mechanics and safety of the team’s vehicle used in the “capture the ball” challenge. Chad was called in to assist the Robosub team within the last two weeks of preparation. During that time, he served as a generalist working on both the software and the mechanics of the Robosub.

For Chad, motivation is about being pushed and challenged beyond just making the grade. As he described:

When you go to school, you kind of just . . . learn the material; you go through it and call it a day. You know, you do your homework. . . . You’re motivated by grades, I guess, but you’re really motivated to learn when you’re learning this stuff and in an environment where it’s pressuring . . . or you’re being pushed to your limit. You . . . actually want to gain the knowledge. I feel like you learn so much more that way. I’m much more motivated at that point than I am, you know, sitting in a classroom.

Chad also shared that he enjoys being challenged to do something that others think cannot be done. To illustrate his point, Chad brought a video artifact with him to his interview. The video inspired the following dialog:

There was that moment where things started working like [in the] videos and . . . and it was kind of . . . it was actually motivating that [the judge] had no faith in the quadrotor. He thought it was a novel idea, but he actually had no faith and when I showed him . . . it was actually fully taking off flying outside and landing. He was, you know, taken aback definitely and speechless for a second, which was . . . that click. . . . It was that point where I’d done something that other people hadn’t done before. Those videos have actually been able to prove these [quadcopters] work.
Chad was one of two participants in this study that was on both the Roboboat and Robosub teams this year. Roboboat and Robosub were Chad’s fifth and sixth engineering design competitions, respectively. With multiple engineering design competitions under Chad’s belt, one might assume that math and engineering come naturally to Chad or that he competes in these competitions because he naturally excels in the subject. However, Chad shared that he has never really been very strong in math:

I definitely struggled through most of my calculus classes . . . and even . . . had to audit two of them. . . . It’s . . . definitely a struggle for me. I think because . . . I was never a super strong, math student, . . . I mean, I do get the material, but . . . the amount of raw, mind-numbing-like practice, to be on the level of . . . um, to be really practicing that I have to do personally ‘cause I'm just not very strong in the subject, um, is discouraging. You know, it just is tough to put in the effort. Now that I'm a little older, I definitely realized that, ‘Hey, I need to put in five times the amount of work in this class to get the same grade as I do in physics or my 400 level ME classes.’ I need to put in more work for that just because it’s something I'm weaker at.

What Chad does not struggle with is involvement. Chad is a highly involved student who participates in numerous engineering competitions and serves as a research investigator for an unmanned, aerial vehicle, undergraduate research project. His participation is not surprising given that he stated he learns best in “project-based learning environments.” In addition, to these hands on learning activities, Chad is also an active member of the university robotics association. Like his teammates, Connor and Tristan, he also is an active member of the university’s fraternity and sorority community. Chad actually referred to his fraternity membership several times during his one and a half hour interview. Chad used examples of his fraternity membership and experiences to explain how he had learned about small group interaction and success and
failure, and how these lessons were utilized from time to time in the group dynamics of the engineering competition.

When asked to reflect on his learning during his fifth and sixth competitions, Chad listed a number of them, stating:

What I learned . . . definitely . . . a lot about controls. Controls definitely were a big part of the competition, and that’s one of the things that weren’t or was not completely developed . . . The guy who was writing the software, he just didn’t have huge controls knowledge, but we definitely learned a lot about that ‘cause we had to rewrite a lot of that at competition. We had to modify that as we went.

There was also a lot of . . . grounding issues, is what we think it was . . . I learned basically . . . how to tune a quadcopter. I learned a lot about . . . interfacing with the computer . . . using zero interfaces and, . . . I knew a little bit about the visions of the torque, but this was a . . . different kind as the control that we wanted to use for it and the control that we saw . . . as best use would be . . . a stepped bang-bang controller so a very basic proportional controller, which is really interesting, but, um, that was something that we . . . learned, um, while I was there . . . working on the project.

When asked if Chad thought there was going to be a seventh competition in his future, he sang their praises, but he was not quite ready to commit. He instead shared these insights:

I think that . . . they’re a large contributor to me enjoying my college career. I learned a lot from them. I got motivated to take classes I never thought I would even enjoy. And, it really, you know, gives me an interface with the industry and I think I . . . see tons of advantages and I think the only thing that I don’t completely love about them is the fact that they’re during the summer, which is kind of difficult to do all . . . summer so you’re kind of, uh, stuck. Not stuck here, but you’re tied to your team instead of going off and pursuing other, you know, more traditional-like . . . internships and something like that. So, this year . . . I’m planning on doing an internship and sort of sticking around. I love my team and everything . . . but I feel like I wanna experience something different too.

Chad is a caring individual who sees the positive in nearly all situations. As a young child, he and his brother were moved from family member to family member while their parents sorted out their lives and overcame alcohol addiction. Chad has
overcome the instability of his childhood and found the positive in his father’s strictness, calling his dad one of the most influential people in his life. As a child, his father was strict and demanding. Today though, Chad says he still looks to be challenged and pushed in order to be motivated to learn.

Connor

Connor, a 23 year old master’s student in mechanical engineering, is a natural leader, is outgoing, and extraverted, and is usually surrounded by team members and friends. While today he seems to be the center of attention, he shared that as a young child he was often alone:

My parents got divorced when I was three, and I spent most of my time with my mother. We moved around a lot. I changed schools a lot and had to frequently make new friends. My mom worked a lot, so I never really saw her and spent most of my time on my own after school. But, she made good money so my childhood was fine, but it probably wasn’t normal compared to other kids.

At first Connor was a bit uncomfortable sharing about his family; he shared that it is something he does not think about or talk about much. When he did share, he spoke about it as being lonely, tense, and filled with strife. Connor described the experience by relaying this story:

I didn’t have much of a family life. I never saw my mother because she was always working. When she was working very late or out of town I would stay with my aunt and cousin. I didn’t enjoy staying with them. My cousin and I are the same age, and we were always fighting and arguing. After my parents got divorced, my father moved back in with his parents. My grandparents were not happy together and my grandfather frequently said, ‘If divorce wasn’t so expensive, I would have gotten one a long time ago.’ So, they always argued with each other, and my father always fought with them. So, it wasn’t fun visiting them either. The more I think about it, I realize that my childhood was mostly filled with arguing and fighting.
While Connor and his mom were on their own, Connor attended a private Catholic school. Connor shared that he did not do very well there, and he was eventually placed in remedial classes. While struggling in school, Connor was diagnosed with ADD and was medicated with the hopes that this would help “cure” an otherwise bright kid who was performing badly in school. Connor described being on the ADD medications as being detrimental rather than helpful:

When I was in first grade I was diagnosed with ADD and put into remedial classes. They put me on medication to help with ADD, but the drugs actually caused depression. I was never in a good mood. I argued with my parents, my teachers, and everyone. After a few years of the ADD medication, they decided that I didn’t actually have ADD, and they took me off the drugs. I have since done very well in school. I never did my homework because I just didn’t want to. I think I only struggled in earlier grades because I was bored, but I can’t confirm that.

Eventually Connor’s mom remarried and Connor, his mom, and his stepfather moved a few hours away from his home. From fourth through seventh grade, Connor began to come into his own as a student. He became known as a bright kid who could do difficult math in his head.

Connor describes most of his schools as being in very affluent areas; however, when his mother got her second divorce, Connor was moved to an eighth grade middle school which was in one of the poorest neighborhoods in town. The school itself was rated as the worst middle school in the area. Having moved from town to town and attending four different schools between first and eighth grade, the stability he found in high school was a welcome change. It was during high school classes that Connor realized his future was in robotics. As Connor recalled this realization, he went on to say:

In high school, I didn’t know what I wanted to do. I took a class called robotics and found out that I was pretty good at programming. So, when my teacher asked
if I wanted to help start a robotics team, I joined, and we did really well for the two years that I was involved. I chose engineering because I was good at it and it was easy for me. It just came naturally to me.

Being on the High School Robotics team meant that Connor was by far the most experienced engineering design competitor of anyone on the 2013 teams. Since entering college, Connor has competed in 20 competitions, repeating several competitions every year since he was a freshman or sophomore. Along with Chad, Connor participated in both the Roboboat and the Robosub competition this year.

On paper, Connor was not the captain of either the Roboboat or the Robosub team. Rather, he served as a backup project manager. In this particular role, his responsibility would be to assist the team captain on strategy and accomplishing the overall mission. However, due to his seniority and his experience, an outside observer would have definitely mistaken Connor for the established leader.

Connor’s philosophy on motivation is that it is a drive or a sense of internal desire to discover new knowledge, stating:

Uh, well, it’s about . . . actually going outside of classes to do research on your own, try and figure it out for yourself rather than having it, you know, spoon fed to you.

Connor was very clear about how he learns best. He was quick to share that he has to be challenged. Anything too easy and he is bored, too tedious and he doesn’t retain the information, too hard and he would give up. He defined challenge as something that he doesn’t already know how to do, sharing:

Being challenged is something that I don’t know how to do, uh, and even more challenging would be something my professors don’t know how to do. ‘Cause, you know, when I’m doing something new to me, I can go to a professor who does understand it, if he’s an expert in the area. It would be like, you know, ‘Can
you explain this to me?’ and he’ll sit down with me and talk me through it. But . .. with some of the things we’re doing in robotics, even the professors are like, ‘Well, I don’t know if that will work.’ So we have to actually test it, and that’s a challenge in itself, you know, actually making the thing, creating the testing environment, and then testing it. Collecting the data . .. the whole process is challenging. It’s a feeling of accomplishment when you’re done . .. I think. It’s just like once you’ve completed it, you’re like, ‘I understand this now. I can do this again.’ And, you know, understanding something is . .., to me, it’s really good. Because then . .. I know that if I encounter this in the industry when I get a job . .. I’ll be able to handle it, and that’s definitely a benefit.

In describing an easy course, he shared that the problem was the lack of a challenge:

Some of them, I had the material previously, like just through my own robotics research or through a class from high school, that kind of thing. So those classes were just really simple . .. ‘cause I already have a pretty good understanding of the topic. Um, so, you know, the professor was not really introducing anything new or challenging, because I’m like, ‘Oh. Yeah, I know how to do that’ or if I don’t know how to do it, I do know how to find out how to do it. Like . .. I know the keywords to Google.

Like all of his teammates, Connor shared that he finds lecture-based courses both tedious and boring, asserting:

I didn’t really have motivation to learn in those classes. It’s just that, you know, the ‘death by PowerPoint’ thing I would, you know, cram the information in, and then as soon as the test was over, I’d lose the information, right? I just forget it. So . .. I wasn’t motivated to learn it or keep it, apparently.

While Connor is one of the first to admit that while he loves a challenge, he does have his limits. In fact, he said that making a situation too challenging will prevent him from learning and demotivate him:

If it’s too hard, um, if it’s something that I can’t reasonably do in the timeframe, and if I am aware of that, I’m aware of the fact that I can’t do it, then that’s not . .. interesting to me. That’s just an academic exercise showing me that I can’t do something.

As one might imagine, after 20 competitions Connor believes in the benefits from engineering design competitions. He explained the benefits in this way to me:
The benefits that I’ve gotten from doing these competitions are immeasurable, just huge. The things that I’ve learned that I wouldn’t have learned any other way—things that I’ve learned through doing these competitions before I learned it from class—[have] made my class just easy, so that was nice. It’s just a matter of, you know, the learning, the networking, the opportunities to do the things that I wouldn’t have gotten to do in the classes definitely makes these competitions worthwhile.

While Connor never admitted it, he seems to have been profoundly influenced by having been alone as a child. Today he is always surrounded by people and seems to thrive and be motivated by being surrounded by classmates and fraternity brothers. Making friends seems to be an easy task, probably because as a child he was forced to make new friends every other year or because he is a naturally gregarious individual. Motivation for Connor is equal part intrinsic and extrinsic, but above anyone else on either of the two teams, Connor seemed to be the most focused on how engineering design competitions can lead him to a career in the future.

**Darian**

Darian is a 30 year old, transfer student who is also a veteran. Darian comes from an Asian background and is following in his mother’s footsteps by going on to college. Darian is in his second year of his master’s in mechanical engineering. Darian is an extremely reserved young man. He is shy by nature, but he also displays the signs of a strong leader. When Darian spoke, people took note, as he was not one to speak unless he had something extremely important to contribute. Darian shared that his shy nature has always been both a weakness and a great strength:

In this case, a quality that addresses both my strengths and weaknesses is my quiet and reserved nature. It is my weakness because there are times when I have a valid input into a discussion and hold back because of my shyness. This enables people to have a low expectation of me and when my hard working ethics prove them otherwise, it becomes my greatest strength. This personality trait also
allows me to genuinely listen to someone and gives me the ability to be conscious about my environment.

Darian is very proud of his heritage and considers his family his biggest influence growing up. Darian brought multiple pictures of his family to the interview and was able to share how each person in the pictures were sources of influence and strength. Darian went as far as to share that his personality traits are because of the direct influence of his family. He shared that the best part of who he is comes from his family. Specific traits that he attributed to family members included learning to be more accepting and understanding from his mother and grandmother. Having a strong work ethic and striving to work hard and provide for the family were traits he learned from both his father and grandfather, and taking on responsibility in both his professional and personal life, he attributes to his sister.

With this close relationship with his extended family it is no wonder that he described how important it is for him to set an example for his nephew. Darian believes that he has a duty to be an inspiration to his nephew and assist his sister, who is a single mom. He shared that he wants to show his nephew the value of hard work and the importance of education. As for other members of his family, he shares he is dedicated to being successful in order to provide for them in the future:

As my family has been the pillar of my existence, my dreams and aspirations revolve around them. Through hard work and dedication, I would like to show my family that their hard work and time spent behind me was worth it. I would like to provide for them in every possible way.

True to his reserved nature, Darian would not share much about his past other than to say he had a very happy childhood with his family. He did, however, share that
he has always known he would work in mechanics and he has always been curious about how things work, stating:

As far as I can remember, I have always had an interest into the internal workings of everything in sight. In an attempt to explain the working of these things, I have embarked on a rigorous path of engineering.

Roboboat is Darian’s 14th engineering design competition. Darian began his role as a mechanic generalist. However, due to issues during the competition, he spent most of the week-long competition focused on engines and propulsion. Darian has a sense of calm about him; this was observed in the interviews and during the competition. Darian has the ability to remain calm during pressure-filled situations. On multiple occasions during the competition and practice runs, when others were running around trying to figure out failures, he would calmly analyze the situation and offer suggestions to the team.

For Darian, motivation is derived from those he sees as having already obtained what he wishes to obtain. He gains motivation from being able to see himself in the same space as those he looks up to as successful engineers. Darien described his motivation in the following way:

For me, motivation to learn is something that . . . encourages you to gain the knowledge that’s out there for you, going beyond the average classroom experience to, uh, get the skill set that you, as an engineer, or an operator, or human factors person are going to need in the job field two years from now, 10 years from now. So that’s motivation—to seek out the skill set that you see in someone that’s currently working in an industry, or you might see that they're highlighted in one of the magazines. You're inspired to be in that position and you seek out those skill sets through experienced learning, theoretical learning, or whatever it may be.

When it comes to how Darian learns, he pointed out that he neither enjoys nor is good at taking tests and instead prefers a more demonstrative assessment, sharing:
I personally . . . don’t like to take tests, . . . I can understand the material when it comes time to . . . regurgitate it . . . in a certain standardized format. I have problems with that, so I tend to excel better in classes . . . that don’t have . . . tests or quizzes, but it’s more of your performance-based . . . classes.

Equally interesting to how Darian learns is why he wants to learn, which also speaks to his sense of motivation. He reflected on this sense of motivation and disclosed this information about himself:

Well, I think one of the biggest challenges for me has been . . . I’m older than the normal average student. . . . I was in the military for a few years, uh, and I went to school elsewhere, then I transferred here. So the environment has been a constant . . . change for me. And, uh, coming to school has been hard to kind of sit in a class and I don’t . . . see the level of maturity that’s in a class. That’s been different, especially from my perspective. And sometimes it hinders my learning because I want to learn in a certain aspect. I want to know what the applications are, but, you know, you have freshmen and sophomore in class that are just focused on learning the material to get an A in the class or a B in the class.

I’m focused more on learning to learn—to better myself as a person. That’s the whole reason I decided to continue my education. . . . After the military I had the option of just not, you know, going to school anymore, but I decided I wanted to better myself as a person. So . . . education will be the venue that I would do it through. And I came here to learn things that, you know, what would benefit me as a person . . . beyond the job field—taking classes, like speech, where you get to learn to interact with people. . . . It's been hard to see that, you know, and when I . . . ask questions, it's different than when somebody else might ask questions, just to figure out how to get by on the subject. But, I'm there to actually learn.

Darian goes on to share how important it is for him to have an engaging and respectful relationship with his professors, and how this is the environment that is conducive to his learning:

Well, I . . . had experiences where . . . professors . . . speak from the PowerPoint slides word-to-word and I’ve taken . . . the advantage of copying the slides from blackboard and printing them out before class, and I bring those to class. So that it gives me the opportunity to add notes to it if there's something different. But, they say the exact same thing that’s on the slide, so it's not so much a waste of my time, I would say, but . . . I want to learn something beyond what's on the slide, you know. I'm capable of reading, so tell me something else.
You know, I'm here to learn. I'm not here to learn from a sheet, because . . . I can go Google™ that, and I can get that same information that might be available. And go to public library and get that same information, but tell me something beyond, you know. Share your experiences, maybe in the field or something else, beyond the normal teacher-student relationship that I experienced in my undergraduate. On the graduate level, it's more of a professional relationship with the professors that I have.

When asked for specific things he learned from Roboboat, Darian talked about learning from failure, stating:

You know, last year our code worked great . . . It was a different language and then this year we decided otherwise and we went to a whole different language and redid that code. All we needed to do was just modify the code a little bit, and that would have given us a much better success rate than we had this year. But, you know, someone else didn’t like the code, or . . . there was a personal thing, and they wanted a different code. So we went that route, and it didn’t work out for us. So this year I’ve kind of expressed that, uh, you know, . . . seeing our track record, I'm sure that, you know, ‘Hey, this worked. Let's keep it the same. Let's not change it.’ We've seen this in the past years, so I've, kind of, taught them and showed them my perspective: that if it worked, let's keep it the same. If it hasn’t, let's try and improve on that particular system itself.

That failure has . . . almost inspired me to learn different things or, you know, for example, we failed on the software side a little bit, so . . . I've tried to, you know, stand behind . . . the software person's shoulder and see what they're doing. Maybe I can. . . . There might be an input that I may have. Or, we feel that because of, you know, the thruster is failing, so right now . . . it's taught me to work from . . . a business aspect of things rather than just an engineering aspect. Darian was quick to clarify that while he saw most of his learning being derived from fixing failures of the system, he did not consider the competition itself a failure.

Whether you . . . get the prize or not, that’s a different story. The money always helps, but you're they're for learning. Especially me, I'm there to learn something and, for me, . . . I learn a few things that I would have never learned in a classroom setting. So I wouldn’t necessarily call it a failure. I think it was a success for me, because I was able to meet people . . . from different universities, . . . meet people with the association, with the organization, . . . and experience things that I wouldn’t have otherwise.

While Darian’s official role on the Roboboat team was as a mechanics specialist, his true leadership came as the team’s emotional anchor. When others were fretting about the loss of propulsion, Darian served as a calming influence on the team. While he
describes his demeanor as shy and unassuming, his teammates see him as steady and influential. Darian’s team seems to serve as a family away from home while he is at school as he counts both his faculty mentors and his team members as heavily influential on his motivation. However, Darian’s devotion to his family is the number one driving force in all he does. From this he is motivated not only to learn but also to be motivated in all his life decisions.

**Lewis**

Lewis, a 20 year old Caucasian, is a junior who is studying computer engineering. At the time of the interview, Lewis had competed in three Robosub competitions, having participated all three years of college. While he is considered a Robosub veteran, he has never competed in any other engineering design competition. For this year’s competition, Lewis served as one of the software specialists.

Lewis described his childhood as typical, saying that it was relatively middle class. He grew up in a two parent household; his mother is a teacher and his father is a police officer. In addition to his parents, he has a twin brother. Unlike some twins who are impossible to tell apart, Lewis shared that he and his brother were exact opposites:

> It was fun always having someone there that has your interest at heart, but we are total opposites. He is very competitive, and I am just not as much as him. He makes everything competitive like: ‘What did you get on that test and what did you get on this?’ Now that he is doing his own thing, I don’t feel like we compete as much. He is doing a double major in English and music, and English is not my thing. Pretty early on, we realized we had different interests. Even from the beginning, he was talking before me, but I was able to read before him. I had more common sense than him, too. I always felt a sense of support though. We had the same classes, and it was like, ‘Okay, what test do we have tomorrow? and ‘let’s study together.’
Lewis and his brother both attended public schools from kindergarten through high school. From the sixth grade, he and his brother were placed in all AP classes. In his school system, being placed in advanced classes meant that he and his brother had the same classmates for every class. While other students and previous friends were still on the same middle and high school campuses, they were never in any of the same classes with Lewis. However, according to Lewis, being separated from his friends was not really a problem; it allowed him to really get to know his consistent classmates better and allowed the cohort of students to really help each other out. Lewis confessed that this made it easier for him because he doesn’t really enjoy making new friends that much. He elaborated that he considers himself shy and not outgoing and that his twin brother was much more outgoing and the one that never stops talking.

While he has never seen his introversion as a hindrance, he did admit that he would never initiate a conversation with a faculty member directly:

I don’t have a lot of motivation to go up to my professor. I would not feel comfortable going to a professor and asking for other help. I have other friends who would go right up and ask or even text the professor, but I would not feel comfortable asking them for help.

While Lewis may be shy when it comes to talking and expressing himself with words, when it comes to music he has no problem taking the stage.

I was involved in Marching Band all four years of high school. It was my favorite time of the day. It was the one activity that I really enjoyed in high school. I really enjoyed that I got to hang out with so many other friends. I eventually became the band’s logistics coordinator which gave me a chance to really get involved in hands on work and organizing and stage work. I also got the chance to do a lot of the truck loading and trailer loading. It was a lot of fun figuring out how to load way too much stuff into a small, little trailer. I realized from that that I really like projects that require spatial recognition. I really enjoyed my time in band. My first year in college, I was in the pep band but unfortunately time issues required me to quit.
While Lewis expressed a real passion for music, he was clear that it was an extracurricular pastime, something that he enjoyed but that he had never considered it for a career. Moreover, he was clear that he has known since childhood that he was going to become an engineer, sharing:

I always knew I wanted to be an engineer, even as a child playing with Legos®. It always seemed so natural to me. I can remember times where my brother and I were building things, and he would have to read each step of the directions. For me, it just fit in to place. It seemed so natural. I might skim the directions, but it was so obvious that this goes here, this goes here, and this goes here.

Congruent with his self-description, Lewis was quite shy in his interview. His demeanor was quiet, and he was very thoughtful with his answers without appearing to be anxious. While his answers were succinct, he did articulate and share striking insights into how one can be motivated by a perceived failure.

Lewis equates being motivated to having desire. He suggests that it cannot be something that others want you to do; it has to be something that you want to do all on your own. Lewis maintained that:

To be motivated to learn is to do something because you want to yourself, not because a professor . . . wants you to. So like if he says, ‘Here’s your book.’ You actually open the book up yourself and read because you’re interested in what it is, not because you have to for a grade or anything.

In Lewis’s interview, he shared that he is a hands on type of learner, but not just any hands on project will do. Lewis added that the hands on project must be accompanied with his interest in the project and a connection to a real life situation. The following exchange between us clarifies what type of hands on learning Lewis finds most motivating:
Lewis: For me . . . hands on activities, definitely a more independent mindset, and if the subject matter is interesting, like not English but more science stuff.

Aaron: What makes a subject matter interesting?

Lewis: For me, it’s hands on activities like real-life applications.

Aaron: So editing a newspaper might be something that’s a hands on activity, but probably from your last statement you don’t like English . . .

Lewis: Not English.

Aaron: So can you pinpoint what type of hands on activity really helps motivate you to learn something?

Lewis: For me, like programming, designing stuff like actually building stuff, screws, screwdriver, hammer, stuff like that.

Aaron: Okay, so working with your hands?

Lewis: Working.

Aaron: And do you find that you can learn from those things without direction or do you prefer to have some sort of direction? How does that work?

Lewis: For the most part, no directions [or] maybe something that gets you in the right direction.

In Lewis’s interview, he shared the importance of having an engaged and creative professor or mentor. He shared the need for a professor or mentor who can lead a class through a project rather than lecture or pass on points from a book. He stressed the importance of an engaged professor who can make connections between student learning outcomes and the real world, stating:

Don’t just talk about microprocessors . . . We have the labs. We actually like to do hands on stuff, each week [make] . . . a different thing, so maybe . . . interface that with more hardware. Make each week . . . something different; . . . at the end of the class have . . . an actual working . . . final device, not just knowledge
and stuff.

In terms of what learning occurred or what action was taken because of the motivation to learn, Lewis shared that:

There is lots of learning, just like learning about light... learning the ins and outs of what works, what doesn’t work, and it’s just also like a huge competition. All the teams there just looking at ideas and just seeing how like that’s not the best way of doing it. It’s a competition so you just want to see what’s there, see how the people did it, see how it works or doesn’t work, and then go back next year and do better.

When discussing the context in which he was motivated, the concept of learning outside the classroom was discussed during the interview. In his conversation, Lewis compared class learning to experiential learning. He shared that in the class one is expected to memorize concepts, whereas in the competition people are able to utilize those same three concepts, explore, and learn. So when one or two of the concepts don’t work, Lewis did not see them as failing but as a process of elimination. He described this process of elimination in these words:

In the competition, you need to make it work; it doesn’t matter like, I guess, [in] classes [it’s] like memorizing the three techniques being this. Whereas competition is like, ‘Okay, I have these three techniques. Which one will actually work?’ And, it’s moving to like try them out and then see, ‘Now, okay I have tried these two techniques. Now I’m going to try this one.’

Lewis is an introverted young man who enjoys understanding how things tick. He compared his passion for understanding computers to that of a clock maker. He stated that he wants to know what makes computers operate in the same way that clock makers want to know how clocks tick. Since playing Legos® with his twin brother, Lewis has always had a natural inclination toward engineering and enjoys challenges of how to make the unorganized organized. Lewis states that in order for him to be motivated,
learning must be couched in hands on projects with real life applications. Not one to be held to directions, Lewis is quite comfortable being a self-directed learner with minimum guidance from a faculty member.

**Tristan**

Tristan, is a 23 year old Caucasian male who is currently working on his master’s in mechanical engineering. Both Tristan’s mother and father completed college making him a second-generation student. Tristan’s younger brother is currently in college, as well.

Tristan’s earlier education was a roller coaster of both good and bad learning environments. Starting in one state, which Tristan considered a strong educational environment, and moving to a new state with an educational environment that Tristan compared to taking a year off from learning. Tristan and his parents considered the education system so bad in the second state that before finishing high school his parents sent him to an all-boys boarding school in order to be better prepared for a college learning environment. Tristan shared his story in the following way:

K-11, I spent in public schools, K-10 in [one state], and 11th in [another]. They were both smaller schools with 150-200 per class. The first . . . was a much nicer learning environment. A vast majority of the students wanted to be in school. They were engaged and challenged each other. The teachers were able to be very open with the students and talk about all topics. The second . . . , on the other hand, was very much the opposite. It was more of a daycare center for below average students. The school was ranked number two in the state, but the classes I took as a junior, where dumbed down versions of the classes I took in 8th and 9th grade. There was a lot of violence, drugs, and ignorance that did not make it a good learning environment. Issues in the [second state’s] public schools gave me the opportunity to [attend] an all-boys, private school in yet a third state. This was by far the best thing that happened to me in high school. I went from being top 10% . . . to top 1% . . . to top 40%. The students were very driven, and intelligent. That year helped me prepare for college, after taking the year off in the second school.
During the interviews, Tristan was the participant that seemed the most comfortable with the process and often would lean into the microphone to be sure that his answers were picked up by the iPhone and redundant digital recorder. This confidence may be explained by Tristan’s early independence, a trait he gained as he was growing up in what he describes as a lower middle class family:

We were lower middle class. We had enough money to have a warm house, running cars, food on the table, and sports equipment, but nothing else. There wasn’t any traveling or toys. My brother and I got jobs very young to pay for things we wanted, and often loaned money to our parents.

I have always been a very independent person. During the summer when I was 13 I moved into a spare room at my grandparents’ house, and got a job at a local restaurant. I paid for my own food and transportation around the island we were on. I did this for two summers. My parents gave me a lot of room to explore and do things on my own. It has made me a stronger, more independent person.

Tristan displays a sense of self-confidence that could be construed as cockiness if he wasn’t so quick to laugh at himself from time to time. This ability to laugh and be lighthearted became handy when months of Tristan’s work as the Roboboat’s hull designer and manufacturer were literally crushed at the turn of the knob. During the design of the Roboboat, the team chose to have Tristan design a new hull. Tristan went through every step of creating the new hull from conception to manufacturing. It was in the final phase of waterproofing the hull when disaster struck. The hull had been placed in a pressure chamber to seal the waterproofing. This process takes hours. Tristan and several of his teammates left for lunch when a member of another engineering design competition team came in to use the same system and turned a docking valve on, crushing the hull nearly instantly. Tristan relayed this experience when he shared his thoughts on learning from failure, stating:
We learned... about different types of materials. We learned about different types of manufacturing processes. The only thing that... we didn't do is learn about how docking valves work. (laughs) Um, we did shut one off, and the SAE team turned another one on and destroyed everything.

When asked what was learned from this experience, Tristan jokingly said to “try not to make the same mistake again. I mean... you're learning all along the way, too”. It’s this sense of learning throughout the engineering design competition that makes it so rich for the participants, as Tristan pointed out:

I don't think anybody likes to see things fail. You know, in science and engineering, things fail... sometimes it's okay... as long as it's not a programmatic failure... Something still happened and you still learned something from it.

The Roboboat hull is just one example of Tristan’s ability to pick himself up and keep going after disappointment or failure. Tristan shared that when he was growing up, engineering was always his backup plan. He originally dreamt of being a Navy SEAL. However at the age of 15, a water polo accident permanently damaged his ear drum and left him no longer able to dive underwater without wearing specialized headgear. Tristan shared that this accident disqualified him from his dream. Not to be one that is counted out, Tristan moved to his backup plan of engineering and is succeeding in graduate school with a 4.0 grade point average.

Roboboat is Tristan’s fourth time competing in engineering design competitions, having also competed in the Intelligent Ground Vehicle Competition, International Aerial Robotics Competition, and the Extreme Redesign Challenge in the past. While Tristan represents himself as a very happy individual having a smile on his face nearly the entire interview, he was very serious when he began to discuss his competitive side, going as far as to say, “I personally hate to lose more than I like to win”. Engineering design
competitions are not the only way that Tristan expresses his competitive nature. He has also competed in a number of warrior dashes and mud runs which allows athletes to pit stamina, skill, and luck against an endurance race and a number of muddy skills based challenges. Tristan is known on campus as an athlete and, as mentioned earlier, is one of three team members who are active members of the campuses’ fraternity and sorority community. Tristan played two varsity sports in high school, swimming and tennis. He was a National Honors Society member and an Eagle Scout. As an undergraduate, he was the public relations chair for his fraternity, and under his leadership, his chapter won an award for the best public relations program in the nation.

Realizing that Tristan is both athletic and competitive provides an interesting context for how he defines motivation to learn. He describes it in the following reflection:

I mean, it's the way you succeed in anything you want to do. I mean, if it comes as school work or sports or whatever you want to do in life, if you're motivated to do it, motivated to, you know, dig deeper into it and learn more about certain or anything, . . . I think that's just the whole point of doing anything (laughs).

It's like . . . an inner drive. You wake up in the morning, and you're like, ‘Uh, I don't really want to work out today, but no, I'm going to work out today.’ Or, you know, don't go out with friends, go do your homework. Or just, you know, being able to have self-control and driven to do something.

Like all his other teammates, Tristan finds learning easiest when it is tied to the context of a hands on project. Unlike many of his teammates, he was able to articulate a value in lectures and PowerPoint slides, but he shares that students do not make meaning from these lectures and PowerPoints until they have a chance to experience a related situation. Tristan said it this way:
I'm a huge fan of hands on things and projects. You learn a lot from lectures and slideshows and those sort of things, but I don't think you really . . . comprehend what you're doing until you actually put it into practice.

Putting learning into practice was another context for when motivation to learn occurs. Tristan shared his belief that learning and learning motivation comes about much easier when individuals can see how it relates to a real life situation:

It’s very, very close simulation to what we're going to be doing. I don't think reading a book or watching a PowerPoint or hearing a lecture is going to . . . teach us those skills. I think . . . actually doing it and . . . being able to work . . . with professors and . . . a school that allows us to have failures.

In terms of an engaged professor, Tristan believes that engaged professors help optimize learning in a course. When asked to describe an engaged professor, Tristan shared:

They'll talk to students. They're very excited about the topic they're teaching. They're very excited about . . . the ability to be able to teach this to people. They're willing to sit down with you anytime. They'll actually . . . engage with you and say . . . ‘How are you doing with this? Do you understand this particular topic?’ I had a class last May where I kind of dazed off and one of the professors . . . just jumped right on me and he started making sure I was paying attention and understood what was going on, what was happening in class.

Tristan was also able to point out an example of a faculty member that was not so engaged. For this particular example, he shared that there was a lack of interest and that the professor’s actions lead to his complete loss of motivation to learn:

I had a particular class . . . where the whole class was PowerPoint, and you . . . came in, he put the slides. [There] were anywhere between a hundred and 200 of them. And he would sit there, and now they're 10 to 30 seconds slides. He'd sit there and click, click, click, click, click. He's just read . . . He'd sit there; he'd look at the screen, read it off and just keep going on through. And then you'd complete a test and he'd just print a couple of slides, read them all over again, show up, take the test and leave. And, uh, I actually got to the point where I just stopped going to class because I could just read the slides. I didn't need him to read them for me (laughs).
Professors were not the only influence on learning motivation. Tristan also shared that teammates can often affect the motivation of the team. Tristan pointed out issues with teammates who have agendas or who want to be the center of attention as having a negative effect on his motivation, stating:

I've worked with people that . . . can be difficult to work with. They get some idea or something else that they are very, very passionate about, but . . . really don't have the funding or resources or the capability to do it and they can, they can be very, very . . . pushy, I guess.

When it came to discussing how the engineering design competition lead to learning or some other act, Tristan shared that his learning went beyond engineering and composites. He went on to say that his learning encompassed lessons on leadership and how to motivate people to take action. Again, he refers to the loss of the composite boat that he had manufactured:

I actually, uh, (laughs) I learned quite a bit of leadership. I'm leaving soon. A bunch of other guys on the team are leaving soon, so we're trying to get new people engaged and trying to get them to take some ownership . . . so they'll stay around and work on it. Last year, I tried to do as little . . . hands on and actual . . . practical design and building as possible. I tried to tell other people “get engaged” . . . I learned a lot. I think we're doing better this year than we did last year, so.

I actually learned a lot about composites. I hadn't done much of that in the past and we got some funding from the Ignite Grant and tried to do some cool new things and, you know . . . I worked with a bunch of the . . . undergrad guys on designing and building and we talked to manufacturers in different groups around campus trying to get this composite boat built and, for our helicopter to land on and it was, it was a learning experience. It didn't . . . end up working out, which was a bummer. We had to revert back to the old one.

For all of Tristan’s self-confidence and independence, he is still a team player who relies on his teammates, fellow students, and faculty mentors to assist him in the learning and motivation process. Tristan has the uncanny ability to pick himself up after failure, and he has used this skill to be able to learn from failure and keep going. Where
at one time Tristan saw himself as a soldier, today, Tristan sees himself as an engineer on
the track to becoming a manager and leader of the future.

Wendell

Wendell is described by his teammates as a source of motivation or
ingovation. His teammates talked about how he had single handedly completed much of
the Robosub coding and how he had been very graceful under pressure. Wendell is
extremely humble and soft spoken. Having a slight speech impediment, he was very
deliberate when he spoke. His affect and demeanor were calming, even when he was
talking about things about which he was clearly passionate. It was surprising to hear that
Wendell was actually the team captain, since he had such a quiet affect. During my
observations of the team, it was obvious that Wendell’s leadership style included more
listening and thoughtful decision making than it did barking out orders. Wendell is a 23
year old African American who is working on a master’s in software engineering. He
completed both of his degrees at the same university and is a second generation student,
sharing that his mother had also completed college.

As a young child, Wendell lived with his mother and two sisters. His father was
only around in the early years of his development. Wendell described his family life in
the following manner:

I lived with my mother and my two sisters. My father was around during my
elementary school years but not much afterwards. I grew up as the middle child
with my sisters, one being a year older and the other being 2 years younger. My
grandparents on either side lived within walking distance of where my family
lived so we would visit them often. I mainly used to hang out with and play video
games with my cousin when we stayed at my maternal grandmother’s house.
For Wendell, there are personal and deep reasons for being motivated to learn. Wendell shared that his childhood was a struggle for him, his mom, and sisters. He confessed that times were rough and that his mother sacrificed to get him to college. He conveyed the importance that his mother plays in his efforts and his motivation to learn. Wendell saw engineering competitions as a chance to continue to learn and to better his grades so that he could someday have the job that would allow him to assist and care for his mother, as she had cared for and assisted him.

Wendell chose not to elaborate about his early childhood, only saying that it was a struggle, but he did share that he did well in school despite these hurdles. He did confess that once in sixth grade, he came home with a failing grade, sharing:

I only ever came home with a failing grade . . . once while I was in sixth grade . . . I [got] yelled at and had my video games taken away from me until my teacher confirmed that I was doing better in class. My mother also came in for a parent teacher conference.

Wendell believes that motivation comes from actually caring and having a passion for the subject. He feels that motivation to learn happens when he is being creative and when he can see a connection with the real world, stating:

For me, it means . . . actually having a drive or a passion to do the things you’re working on. I mean . . . it's more than just classwork. It's like actually being able to do something, to actually be able to create a final product and see your product in action.

For Wendell, his passion for electronics has been around since childhood. He stated that he has always wanted to know how things work:

Growing up, I always enjoyed playing with electronics. I wasn’t satisfied just using them, but I wanted to know how they worked on the inside so I use to take them apart and put them back together.
Wendell has always preferred hands on learning and ever since childhood has had the urge and interest to build and create, sharing:

I've always been more of a hands on type of person, even growing up as a kid, where I was always getting my toys, my Legos and stuff, to actually try and build something.

As an adult, Wendell still sees hands on learning and self-discovery as his best chance of comprehending and learning. He also spoke to the virtues of having faculty serve as a guide for learning, when he stated:

I personally learn more as I'm actually trying to do something because I'm more motivated to actually seek the material, as opposed to having somebody just spit it out at me. And, is basically like in one ear, out the other until you need it for the test.

I'm mostly a self-learner. I just go on Google and . . . look for any available information. So, I like professors that are able to basically guide my search, basically kind of either give me the search terms or even give me points and then that points to other materials.

Like other teammates before him, Wendell shared the frustration with professors who used PowerPoints as their main teaching device. In his own words:

A couple of years ago in one of my classes, . . . I believe it was computer architecture, I kind of dozed off in class. Mainly because the professor was literally just bringing out slide show point-for-point, and then there were some classes where I just . . . would not go at all. I just basically . . . read the slide show, understood the information from that, and in the end, I still ended up doing good in the class because of that. But, that also drives me into really not wanting to learn that information because it's just kind of boring and repetitive.

Where Wendell and others were able to talk about how passive lectures can cause a demotivation to learn, Wendell was also able to relate a story of how hands on learning motivated him to go further in learning than the original lesson required. He said it in these words:

Starting my second year here, it was the Java course for CS. I believe it was 225. The final project was . . . making a cash register. So, that actually taught me a lot
more. In the actual class, I really didn't pay attention too much because, again, it was one of those... slide show[s], but there was also a lab involved. So starting the lab, I learned quite a bit. I actually... did the basic project, but because of that, I wanted to learn more. So I actually added on other stuff that most people would have never done... You have to create a basic cash register but I added an abundance of items... I had... pictures for each item. I had a background and a database for it.

After I started doing the project, I just wanted to learn more about how a certain aspect of the language worked, so I used lessons from my other studies... That’s one of the best ways to learn—to actually do something you're doing, just like really take a feature that you want to add on. Then you go through a step to learn how to add that feature.

When asked to articulate how or what the Roboboat competition motivated him to learn, he shared that he learned a number of transferable skills that he could use in the future:

I learned quite a bit from that competition. Basically, I learned about how small boats work, how they perform in the water. I learned a lot more about programming and doing software for... different types of hardware. I guess the main drive to learn that is that it was an interesting project—something I was really interested in learning how to do. And, I really wanted our team to do well during competition.

Wendell brought with him the laptop he uses for programming, which is loaded with codes. This artifact allowed him to share how he derives motivation from his teammates. When describing the artifact he shared that his teammates helped to motivate him when they relied on him or when they put their trust in him to get things done for the competition. To that point, Wendell disclosed:

I'm known as one of the people in the lab who are good at programming, who knows what they're doing, who can get stuff done. So, that definitely gives me more of a motivation to actually prove them right, that I am that type of person.

Wendell does not just see the team as a source of pressure to win; he also sees groups and teams as an added source of motivation and as a resource for learning. In the engineering design competition, one student may be the expert in mechanics and another
in coding; however, the mechanic may know a trick to the coding, and so can share their learning with the student that is leading the coding team, as Wendell pointed out.

A lot of what I know about systems I learned from somebody else in the [Robotics] lab. Like doing the research on your own, the problem is that you don't necessarily know exactly what you need to research. But having someone else who's done this before, who is familiar with the system, they can direct your focus to one particular subject.

Wendell also explained this sense of being a resource in terms of classroom learning, stating:

If there's something that you really just don't know, really just don't understand, you have a couple of other people who may know the material who can explain it differently, as opposed to the professor or something.

Some of my double-E courses, since those are always pretty hard because they’re like black magic . . . during those courses a bunch of us . . . who took a lot of those classes together, we formed like a kind of a permanent study group for some of these courses. But, one that was particularly hard was . . . Signals and Systems just because the math there. . . . Sometimes you weren't in the right class to actually understand it fully. So, especially in that group, [with] different people taking different math courses at different times. You can have somebody who is more of an expert or . . . who at least took the course could explain some of the more difficult math.

In addition to his teammates and family members, there were others that Wendell believed helped to bring about motivation to learn. For instance, he felt that seeing the advisors being engaged and involved with the team was a source of motivation. Wendell expressed it in this way:

Our advisors that we have are some of the most involved advisors than any other club on the campus. I mean, like [one of them]. He'll come in on nights; he comes in on the weekend. He actually hangs out with us in the lab as we're working. [The other], he does that on occasion whenever he gets a chance to. I mean, if you really see like a department chair come into the lab and actually sitting down with you, looking at what you're doing . . . I find that stuff . . . just really, really helps us.
Wendell is a deeply personal and private young man. You can spend hours in a room with Wendell and not hear him speak unless directly spoken to. While this may have come about from what he called rough times during his childhood, he declined to share more. What he was willing to share was that he is motivated by the thought of one day being rich enough to take care of his mother for all that she has done for him. In addition, he finds motivation from working with his teammates and mentors, pride in what he has constructed as a part of the robotics team, and finds hands on learning to be the most appropriate way for him to learn.

Zane

The youngest of his teammates, Zane was a 19 year old freshman at the time of the Roboboat competition. More than once, his teammates referred to him as the “new kid” even though he looked older than 19. Regardless of his young age and length of time at the university, Roboboat was Zane’s third engineering design competition, and first as the team’s lead computer programmer. Zane also competed in the Student Unmanned Aerial Systems Competition and the International Arial Robotics Competition in the same year that he competed in the International Roboboat Competition. Zane is a naturally curious individual; he shared that he has had a passion for all things engineering and aerospace since childhood.

For Zane, this interest in engineering was perpetuated by conversations with his dad at a very young age. These conversations included long hours talking about electricity and mechanics. While Zane has both an older brother and sister, he shared that he was never very close to either of them because of how different he was from his
siblings. They had interests that were dissimilar to his and were busy with afterschool projects. Zane explained his family dynamics in the following way:

My brother, the oldest, is a musician that is incredibly skilled at many instruments and many musical styles. My sister is a dance teacher, personal trainer and heavily involved in musical theater and is also very talented. My father . . . owns his own one-man company producing custom industrial control systems and automation . . . systems. My mother has recently started teaching at a private school.

I never became close with either of my siblings, partially due to very different passions and partially because of the large number of activities each of the three of us were involved in. We did not spend an exorbitant amount of time together. I can remember when I was younger spending hours talking with my father, him trying to explain electricity, how a certain machine works or the like.

In addition to his dad’s early influence, Zane also recalled a television show that had a profound influence on his interest in engineering, sharing the following story with me:

From my earliest memory, I wanted to be an inventor, solve problems in an original way. When I was about 10, I remember seeing a Sci-Fi TV show called “Stargate Atlantis”. After that there was no turning back, I couldn’t figure out why if we could imagine it, why it couldn’t be built. I read that a lot of science fictions predicts what the technology will be in 10 or 20 years and saw examples that proved the case. I knew that the scientific knowledge would keep growing, and I wanted to help use that knowledge to create spaceships and space stations on exotic alien planets. The only chance of me being able to do that was through engineering.

Zane has never lost the dream of his 10-year-old self. He shared that his dream some nine years later is still to build the spaceships of the future:

One of my many dreams is to work with a team of passionate and intelligent individuals to design and build the spaceships that will both serve as transportation between the planets as easily as one gets on an airliner and will help reignite the human populations drive to explore.

Early schooling for Zane included being homeschooled until about halfway through the third grade. After that, he went to public schools. Zane shared that he was
happy that the school had a music program, which allowed him to be involved in performing music throughout elementary school and into high school; however, he described being disappointed at the lack of engineering related electives or extra-curricular activities in his education. Zane also shared that he was often disappointed with his level of learning, stating, “The majority of my teachers throughout my schooling have left no impression on me, I managed to get through the classes without learning any of the material.”

At the time of the interview, Zane was a sophomore studying aerospace engineering. Zane is following in the footsteps of his father, mother, and siblings, all of whom have completed college degrees.

Even though college attendance runs in Zane’s family, Zane disclosed that college has not come easy for him. He shared that he has struggled in a number of his classes and has fought to keep up with the subjects that he called foundations for even harder courses. Zane stated:

I probably have to go back to . . . Physics or Calculus. As an engineer, unfortunately, I have in the back of mind that these are courses I'm supposed to be really good at just naturally, and that's not the case. They're my hardest subjects, and what makes them difficult is . . . remembering the formulas, getting everything to work together . . . and going into . . . the tests, remembering that you're looking at this problem right off the bat. You're like, ‘Alright, I need to plug this equation in and run with this equation, combine these two ideas and go with it.’ It's difficult for me. I have a hard time remembering things. I don't study enough, any combination of those things.

In order to stay motivated, Zane remembers two things: one, that he will have to repeat the course again if he is not diligent in his studying, and two, that the subject matter in one class will be essential to learning future and more interesting subjects. Zane can get easily bored with his courses. He must see the purpose in a subject and see
how it connects to something he finds interesting, or he immediately dismisses the assignment as unnecessary and not worth his time. Zane shares that busy work is the quickest way to demotivate him when it comes to learning, stating:

Fortunately, I haven't seen a whole lot in college so far, but I got a lot in high school . . . where the example would be in some science class or whatever. I would be writing papers, nothing to do with science and nothing to do with making me a better writer, because the person is not grading me on my writing ability. So, it's something not related to the subject, not . . . at least that I can see that's in any way related to making me better in that subject or a better student in general.

It's hard to judge sometimes because I don't know the full story, and they might have reasons for doing certain things that I don't fully understand, but I always found that . . . homework of course, all that jazz, . . . I understand the reason behind it. But, there's always times when you've gotten busy work from professors and that just ruined any care I had for that class pretty much. That, and, of course, . . . having a teacher or a professor that doesn't care about the topic . . . Then, of course, that makes you care even less.

Zane, however, does care about engineering. He cares deeply, especially about aerospace engineering. He shared that motivation to learn, for him, is a combination of having a “curiosity and . . . the joy of learning.” Zane sees motivation to learn as a sense of “inspiration.” To be inspired, Zane needs an engaged professor who can help him to find passion for a subject. Zane sees professors as two sides of a coin. On one side of the coin, there is an impassioned educator or researcher, and on the other side you have a professor that shows no or little interest. In his own words:

When they're excited about what they're talking about, it comes through their teaching . . . They spend more time talking about the interesting aspects of it and how it applies, because they know, because they spent their own time thinking about it, and it's just that enthusiasm rubs off on the students most of the time.

Someone who doesn't really care too much about the subject, . . . every year they have the same slide show up that they haven't touched in five years. It's exactly the same. They do it for every single class, and they just stand up there and they monitor through the slideshow. And, when they go onto the next slide, they monitor them through that one. So then, you're like, ‘They obviously don't care about the subject because they're not actively learning anything.’ . . . They're
just giving us [the] same old material for us to learn. They're personally not learning any more, or at least not learning that subject.

In addition to being inspired or motivated to learn by engaged professors, Zane also is motivated to learn from working with his robotics teams. “Working in a group . . . means you can accomplish something significantly outside the range of one person.”

Zane believes that the older and more experienced students are educators in their own right and serve as both motivation and as resources to learning. He stated:

Either someone older that has already done it, or there's other people that are more experienced in this specific area, and you can learn from those people. Meaning that it's not like you're splitting off, ‘All right, you do this. You do this.’ It's you are doing that, but in the process, you're all learning all the different parts of it all at the same time.

You know, being the youngest member of the team, it was really nice or it was moving to see where some of the other people were as far as, like intelligence. Real, like, applicable intelligence I guess I would say . . . Where . . . they knew how to make things work, how to . . . be more of an engineer than I was by a really, really long shot. And, that wasn't years in the classroom, it was years in the [robotics] lab. Because they figured out how to make things work in the real world or in our little version of it.

Zane sees engineering competitions as the closest thing he has ever gotten to real world experience. “I guess the closest that I've come to real life . . . as far as you're not given a test at the end of the semester but you're giving a deliverable . . . I mean, you have to finish this by this date.” This real life context provides motivation but it also has propelled him to learn, expressing it in this way:

You have to teach yourself to learn . . . from the other people or professors or teach yourself, from zero knowledge to being able to be the lead programmer in the group by the end of the year is where I went from. So, I think . . . in the classes you learn . . . out of context equations in math, and some professors bring in the context which helps.

Zane is an inquisitive young man with dreams of conquering the heavens. Since childhood, he has seen engineering as the key to making what might seem impossible,
possible. Traditional, faculty-centered learning has always led Zane down one of two paths. For courses in which he saw no value, he passively waited out the course and learned nothing. For courses which he considered necessary, he struggled through, fighting to learn the concepts necessary to move forward. Zane has had to teach himself the importance of devoting time to succeed in difficult subjects. His childhood interest in inventing and creating has manifested itself in his now being motivated to learn through hands-on projects, experiential learning, and authentic-based projects. In his early education, Zane found his teachers to be uninspiring. Yet today, within engineering design competitions, he finds engaged professors and experienced teammates to be instrumental in his learning motivation.

**Summary**

Kvale and Brinkmann (1996) define qualitative research interviews as "attempts to understand the world from the subjects' point of view, to unfold the meaning of peoples' experiences, to uncover their lived world prior to scientific explanations" (p. 1). Each participant’s story is a personal reflection of his experience with learning motivation. There are strong patterns and obvious themes that can be derived from each individual’s account, which will be described in detail in the next chapter. However, the purpose of this chapter was to provide context and a voice to each individual, as well as to amplify those individual voices. Each story brings with it a variation, and with each variation, as slight as it may be, brings a bit of new knowledge.
CHAPTER 5

ENGINEERING COMPETITORS’ MOTIVATION TO LEARN

“Science, my lad, is made up of mistakes, but they are mistakes which it is useful to make, because they lead little by little to the truth.”

— Jules Verne, A Journey to the Center of the Earth

Eight engineering design competitor participants were interviewed for this study in order to understand how their experience with the Robosub and Roboboat engineering design competitions motivated them to learn. The quotes, thick descriptions, and words that comprise the following chapter are meant to synthesize the thoughts and experiences of these eight individuals into responses for four sub-research questions. These four questions include: (a) How do student contestants describe their motivation and ascribe meaning to it personally?; (b) In what context does motivation occur to them, individually and in interaction with others?; (c) Who helped bring about motivation for these student contestants?; and (d) In what ways does this motivation propel them to act, learn, or achieve? Ultimately these participants’ thoughts and responses to the sub-questions provide insight into the main research question: While preparing for and participating in International Robosub or Roboboat Competitions, what experiences—actual acts, specific behaviors, or other moments—bring about motivational responses for student contestants? Throughout the chapter, the words of the participants will describe motivation and include an examination of the context in which motivation occurs to the participants, both individually and in interaction with others. This chapter provides details about the people who helped motivate the student contestants and touches upon the ways this motivation propelled them to act, to learn, or to achieve.
Throughout the process of interviewing the eight participants and following the phenomenological methodology that was recommended by Moustakas (1994), I was reminded of the challenge of Goodall (2008) to add stories to collective knowledge. Goodall inspires me to benefit society with the voice of my co-researchers, who through my research, are able to share with the reader their experiences related to learning motivation. In order to ensure that the responses to the research questions were collected, analyzed, and reported in the most ethical manner possible, a tremendous amount of effort was exerted. Interviews were held and transcripts were created while making sure that each word was authentic and transcribed appropriately. The analysis of the transcription took a personal concentration and a motivation unlike any other assignment I have ever accomplished. To ensure the trustworthiness of my analysis, I vigilantly followed van Kaam’s method as described by Moustakas (1994). I utilized horizontalization, reduction and elimination, clustering and thematizing. In addition, I made a concerted effort to achieve epoche and bracketing, phenomenological reduction, and imaginative variation, which allowed me to ensure that the combination of each individual’s accounts were both cohesive and appropriate.

The results of this are an honest look at the banking method (Freire, 1970) of education that these eight students have experienced and the engineering design competition which they believe is a better alternative. My hope is that this authentic look at the engineering design competitors’ experiences will provide educators with a description of students’ learning experiences and motivation to learn as well as a better understanding of how to use engineering competitions and other “hands on” learning techniques in a way that will motivate their students to learn.
How Do Student Contestants Describe Their Motivation and Ascribe Meaning to it Personally?

One of the hardest questions during the interviews was when people were asked to define their motivation to learn. I asked each participant in several different ways, and each was perplexed. Some called it a very philosophical question and others said it was something that they had never stopped to think about. It is no wonder that we spend thousands of dollars on fitness trainers and diet gurus, buy dozens of self-help books, and employ life coaches all in an attempt to help us to find some sense of motivation because we are often unable to define what motivates us. It is a rare individual who stops and really asks himself the question: “What is it that drives me to do what it is I do?” Yet, when we are motivated, many of us will move mountains to accomplish our goals. Further, those who learn what motivates them are often able to accomplish great feats. After some thoughtful introspection about what it is that energizes them, each participant offered an operational definition of motivation. They then used it to describe motivation to learn. These operational definitions were varied in their explanation, but essentially fell under one of two themes: 1) motivation is an interest in the subject matter and a desire to understand the subject better; and 2) motivation is a feeling that comes from a belief that you can obtain a benefit or meet a goal, because of understanding the subject better. The two themes and the participants who expressed them are shown in Table 2. This table and all other tables within this chapter depict a graphic representation of what is described by the individual participants and explained throughout the text.
Table 2

*How Student Contestants Describe Their Motivation and Ascribe It Meaning*

<table>
<thead>
<tr>
<th>Name of Participant</th>
<th>Interest in Subject and Desire to Learn More</th>
<th>Belief You Can Obtain a Benefit or Meet a Goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Chad</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Connor</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Darian</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Lewis</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Tristan</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Wendell</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Zane</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Both operational definitions and themes follow the motivation research of Deci and Ryan (1995) closely. As was stated in chapter two, motivators fall under one of two categories, either intrinsic or extrinsic. While an individual can be motivated by both extrinsic motivators and intrinsic motivators at the same time, the motivators themselves remain either intrinsic or extrinsic in nature and influence the individual in different ways. Examples of both intrinsic and extrinsic motivators and the different ways that each influenced the participants are explored throughout the chapter.

**An Interest in the Subject Matter and a Desire to Understand the Subject Better**

As was stated in chapter two, Deci and Ryan (1995) provided an example of intrinsic motivation through their story of the naturally curious rhesus monkey. The monkeys in Deci and Ryan’s story were placed in a cage with a mechanical puzzle and because of curiosity, interest in the subject, or inspiration, the monkeys spent hours working out the puzzle. This same philosophy can be seen in the participants’ stories of being motivated to learn because of an interest in the subject matter and having a desire to understand the subject matter. For instance, Connor explained it this way:
The motivation comes from an interest in the topic, things that . . . I’m interested in—software and computers. It’s just something I’ve always sort of been . . . good at and something that I’ve always wanted to understand better, but understanding literature is not just something [I’m interested in] . . . I can read a book . . . I’m literate, but, you know, I don’t wanna look at all of the in-depth details. . . . I guess, it’s more like where I want to allocate my time.

Deci and Ryan (1995) suggest that the motivation to learn, which is internal comes from a perceived joy of learning, rather than a prize, recognition, or grades. All but one of the participants’ responses seemed to echo Deci and Ryan’s notion of intrinsic motivation. Zane, for example, called motivation “a combination of curiosity and . . . the joy of learning.”

One might assume that an engineering design competition is automatically an exercise in external motivation due to the nature of competition or the attempt to win over the other challengers and to win the cash prize. However, Lewis would disagree, stating:

It’s motivation for self-knowledge. It’s not . . . for . . . a trophy or . . . prize money . . . A money prize is given out but that's not entirely motivational . . . That's nice but that's not the main purpose of the project.

To be motivated to learn is to do something because you want to yourself, not because a professor wants you to. So . . . if he says, ‘Here’s your book.’ You actually open the book up yourself and read because you’re interested in what it is, not because you have to for a grade or anything. An example would be your daily chores; you can walk into your kitchen and see . . . dirty dishes all over the counter and that can bug you. So you . . . clean them up for yourself and now you’re happy that you’ve been productive and have a clean kitchen, whereas grades are like your mom: ‘Do chores. Do chores.’ And . . . it gets done in the end but it’s more painful and stressful.

As for the idea that learning is simply about wanting to achieve a grade, that too does not seem to be a motivating factor for most of the participants I interviewed. In fact, Darian specifically spoke to the idea of grades and diplomas when he stated:
My motivation to get an education was not so I could have a degree in my hand, it was to better myself as a person. So I . . . have a whole different motivation set, you know, compared to other people, where they want to get a degree, get a job, get married, have kids. Uh, I . . . want an education to have a different meaning in my life . . . That’s why I'm here.

A second characteristic of intrinsic motivation described by Deci and Ryan (1991) is “the idea that intrinsically interesting activities are optimally challenging . . . for a person’s capacity” (p. 242). A similar sentiment was shared by Chad when he suggested that it is the challenge of the learning that is motivational and not the reward of earning a good grade, explaining it in this way:

You’re motivated by grades, I guess, but you’re really motivated to learn when you’re learning this stuff in an environment where . . . you’re being pushed to your limit. You . . . actually want to gain the knowledge. I feel like you learn so much more that way. I'm much . . . more motivated at that point than I am, you know, sitting in a classroom.

In essence, the participants that described motivation as an interest in the subject matter and a desire to understand the subject better are motivated by an internal curiosity, inspiration, or interest that does not require some extrinsic reward. These individuals are intrinsically motivated for sheer love of the subject.

**A Feeling That Comes from a Belief That You Can Obtain a Benefit or Meet a Goal**

All participants but Adam defined being motivated to learn as an interest in the subject matter and a desire to understand the subject better. However, this intrinsic definition was not the only way that participants described motivation. In fact, all eight, including Adam, described an extrinsic motivation or, as they described it, a feeling that you can obtain something or meet a goal. Before trying to comprehend the reflections of the participants that mentioned extrinsic motivators, it is important to review the dynamics of extrinsic motivators and the difference between them and intrinsic
motivators. Ryan and Deci provide the following definition that can be applied to this context:

In Self-Determination Theory (SDT; Deci & Ryan, 1995) we distinguished between different types of motivation based on the different reasons or goals that give rise to an action. The most basic distinction is between intrinsic motivation, which refers to doing something because it is inherently interesting or enjoyable, and extrinsic motivation, which refers to doing something because it leads to a separable outcome. (Ryan & Deci, 2000, p. 54)

From this definition, it might seem that intrinsic and extrinsic motivation are diametrically opposed to one another; intrinsic motivation seems to spring from internal enjoyment and passion while extrinsic motivation appears to require some external reward or punishment. However, as you read each individual’s profile, and, as you will see reiterated throughout chapter five, the participants’ experiences with extrinsic motivation were not described in a coercive manner as the concept of reward and punishment might denote. Instead, the participants’ reflections seem to show that extrinsic motivators either work as reinforcement of their intrinsic motivation, or the extrinsic motivators seem to be a source of joy and interest in and of themselves creating an inherent interest in learning similar to the way that Ryan and Deci (2000) describe intrinsic motivation. For instance, six of the eight participants reflect on their enjoyment of the competition and their desire to win the competition. While Ryan and Deci and others would suggest that the participants are being extrinsically motivated by the idea of winning a competition, they would also have to acknowledge that these eight students experienced enjoyment from the competitions, similar to the inherent interest in engineering that seven of the participants shared as their source of intrinsic motivation.
A deeper review of the research on extrinsic motivation reveals that the experiences of these participants are not unique to this study. In fact, multiple studies, including Deci and Ryan (1995), Ryan and Deci (2000), Frederick-Recascino (2002), and others, have found that intrinsic and extrinsic motivation are not as dichotomous as one might assume. These and other researchers have found that there is actually a motivational continuum, which is defined by the level of autonomy or control that the person has over the motivator. Figure 8 provides a visual display of the motivational continuum as described by Ryan and Deci (2000) and discussed in the subsequent sections.

Figure 8. Motivational Continuum Based upon Ryan and Deci (2000)

Ryan and Deci (2000) labeled the far left side of the scale as “amotivated” or “unmotivated” and the far right side of the continuum as intrinsic motivation. Within the continuum, there are four domains of extrinsic motivation. The first domain of extrinsic motivation includes the classic concept of being pushed or coerced into behavior by a reward or punishment. This domain is known as “external regulation” and is the realm of motivation studied by Skinner (1953), Pavlov (1928), and Watson (1913). Within the earlier profiles and throughout the remainder of chapter five, there are several examples
where the participants of this study shared external regulation motivators such as the fear of failing during the competition or avoiding a failing grade.

Moving to the right on the scale, the next domain of extrinsic motivation is labeled “introjected regulation”. Students who are motivated by their own ego might fall within this domain. Ryan and Deci (2000) describe this next section as being motivated by pressure or obligation. They go on to say that under this domain “a person performs an act in order to enhance or maintain self-esteem and the feeling of worth” (p. 62). Introjected regulation also corresponds with Atkinson’s (1957, 1964, 1966) achievement motivation theory and with Nicholls’ (1984) concept of ego involvement achievements. Throughout the fourth chapter and later part of chapter five, there are numerous examples of introjected regulation described in the participants’ reflections. For example, deeper in this chapter are quotes from Adam, Lewis, and Connor who believe that they were motivated to prevent the robosub from failing at all cost. Another participant, Wendell shared the importance of maintaining his standing as the best coder of the team.

The third domain of extrinsic motivation is classified as “identification”, which is described as seeing how a behavior might provide a benefit toward a goal. For instance, Connor provided an example of identification when he shared the goal of achieving a job. Connor was motivated to participate in numerous engineering competitions because he identified the benefits that come from such behavior. Numerous other examples can be found in chapters four and five where the participants have identified reasons to be motivated based upon their belief that the work and learning would have a direct connection to their goals. It is this third domain that was most often referred to in the reflections of the eight participants.
The final domain, which Ryan and Deci (2000) describe as the most autonomous form of extrinsic motivation, is called “integrated regulation”. This form of extrinsic motivation occurs when an individual sees the extrinsic motivation as congruent with their goals, aspirations, and values. In short, a person must reflect on the extrinsic motivator and determine that there is no form of coercion, guilt, or fear within or because of the motivator. The person must believe they have complete autonomy, and they must choose to be motivated by the extrinsic motivator. For instance, students who are motivated to go to class because they fear that not going to class will mean they will fail the course are said to be externally regulated. However, if students go to class because they believe it is congruent with their individual principles or because they believe that it is the right thing to do for themselves, then they are said to be motivated extrinsically at the integrated regulation level. In order to be sure that they are at the integrated regulation domain, they must ask themselves, “Will I feel guilty if I skip class?”, or “Do I fear my professor’s or parent’s repercussions?” If the answer is yes to either, according to Ryan and Deci (2000) and others, then they are not truly being motivated at the integrated regulation level, but instead at one of the lower domains. However, if students go to class because they inherently love the subject, then they are no longer extrinsically motivated but instead intrinsically motivated.

Ryan and Deci (2000) point out “the more one internalizes the reasons for an action and assimilates them to the self, the more one’s extrinsically motivated actions become self-determined” (p. 62). Being self-determined is a positive trait as it closely resembles many of the same qualities as intrinsic motivation. For example, integrated regulation motivators are non-coercive, and they have the ability to create a sense of
enjoyment. However, Ryan and Deci are clear that just because intrinsic motivation and extrinsic motivation at the integrated regulation level are extremely similar, it is not possible for an extrinsic motivator to become an intrinsic motivator because the extrinsic motivator is still being influenced by some external value or benefit.

When asked to describe motivation to learn, there were several participants that shared an extrinsic description of motivation, or as Connor described it: “Motivation is being able to see the benefits of something while pursuing it, while trying to understand it. Whatever it is you’re doing—being able to see the benefits and doing it for those reasons.”

Connor sees motivation to learn as a means of gaining a benefit. The main benefit for Connor is being prepared for a job.

It’s just like once you’ve completed it, you’re like, ‘I understand this now. I can do this again.’ And, you know, understanding something is, to me, it’s really good. Because then . . . I know that if I encounter this in the industry when I get a job I’ll be able to handle it, and that’s definitely a benefit.

Where Lewis and the more intrinsically motivated team members saw the competition as a source for self-learning, Connor sees the competition as a benefit, stating:

The benefits of the competition are really important, you know, being there . . . getting a recognition for taking first place. Getting prize money is important. Then, of course, all the people from industry that are there watching, and then at the end, you know, if you do good, they’ll offer you jobs and stuff. The benefits of the competition are really a big motivation to do that, and actually try to accomplish the technical aspects.

You know being in a classroom, you have the stress of . . . another test coming up. I got homework to do, but it’s completely different for the competition. The deadlines are different. I feel like there’s more benefits to the competition, right? I mean, I have to do the class so that I can get my degree, but there’s no immediate benefits from that class, right? When I go to competition, I’m interacting with people from industry, people that are gonna be able to help
me out. I’m networking. People see my skills and my abilities at that competition. So I think that the short term benefits of the competition are much more noticeable. They’re much more prevalent in why we’re doing it. Whereas the class is like, ‘I have to do this, but it’s a long term time to go.’

Adam also shared a more extrinsic motivation for learning, which was:

You want to learn so you can do well on tests and then . . . proceed to the next class, and . . . you want to do well in the competition so you really have to learn like what the tasks are, what can you do for them and different ways or approaches.

For Adam, if you take away the competition, you take away the motivation to learn. He shares as much when he states that without the competition piece of the Robosub experience:

I think there would still be kind of a winner in everyone’s minds like, ‘Oh, I did this many more at things than the other people did.’ So . . . I don’t know. I guess without the . . . competition of it, it wouldn’t be as motivating because as I said before, the motivation would be to do better than the people who are, you know, still ahead of us.

For Zane and the six others, motivation is a combination of intrinsic and extrinsic motivation. Zane shares that “it’s a matter of having a purpose to do something, to have . . . a reason to put the effort into and to actually want to put that effort in.” When asked what makes him want to put the effort into learning, he shared that it was a combination of the intrinsic joy of learning with a more extrinsic idea of meeting an end goal, such as winning a competition or preparing for a career.

Unlike the intrinsic description of motivation, where the participants did not need an outside influence in order to be motivated, this second motivation description is extrinsic and describes the student’s belief that they will gain something from learning. This belief, that they will gain skills for a job or an award for winning the competition, is
similar to other motivational research studies that identified compensation or some other reward as the participant’s extrinsic motivator.

**Summary**

When asked to reflect on how they define motivation to learn, the students saw motivation in two ways; first, intrinsically or the joy of learning a subject they love. Secondly, they saw it extrinsically at the identification level, or they saw motivation as helping them achieve some sort of benefit. However, reading through the next section on context for which motivation occurs, it will become clear that there are numerous extrinsic motivators at all four domains. While the participants might not be consciously aware of all the multiple forces propelling them to action, they are nonetheless at play, and are described in the subsequent sections.

**In What Context Does Motivation Occur, Individually and in Interaction with Others?**

Where the first sub-question was a bit challenging for the participants, the numerous questions that were asked to get to the root of the circumstances in which learning motivation occurs was a much easier task. The participants were very clear about the context in which their motivation occurs, coming up with dozens of scenario-based answers. Based upon their robust answers, six themes or situations that lead to motivation to learn emerged (see Table 3). These themes included the following: 1) Working in hands on situations; 2) When trying to achieve the goal of winning or avoiding failure; 3) As a factor of the competition; 4) In authentic or “real world” situations; 5) Facing deadlines; and 6) When there is a sense of being challenged.
Table 3

*Contexts in which Motivation Occurs*

<table>
<thead>
<tr>
<th>Name of Participant</th>
<th>Hands on</th>
<th>Achieving Goal/avoiding failure</th>
<th>Because of the competition</th>
<th>Hope for a Job</th>
<th>Real world</th>
<th>Deadlines</th>
<th>Challenged</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<td>X</td>
<td></td>
</tr>
<tr>
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<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Lewis</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
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<tr>
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<tr>
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<td>X</td>
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</tr>
</tbody>
</table>

**Working in Hands On Situations**

Whether you choose to call it project-based learning, problem-based learning, projects, or hands on learning, the participants discussed how they are more motivated and learn more when they are assigned to work on a project. While most of the literature uses the terms “project-based” or “problem-based” learning, the students used the term projects and hands on learning. It is not surprising that the students would choose the term “hands on”; nearly every student confessed that they prefer working with their hands to learning by lecture. In fact, several students went as far as to generalize to all engineering students, saying, “Engineers prefer to work on projects”. Chad, for example, said that when it comes to being motivated, he wants the opportunity “to build something from the ground up”.

Similarly, Wendell pointed out that for him and others this interest in building things and working on projects has been an interest since childhood, sharing:
I've always been more of a hands on type of person; even growing up as a kid . . . I was always getting my toys, my Lego's and stuff, to actually try and build something. I know one thing I used to really like doing was taking apart computers . . . That [was] basically what got me into . . . the software and computer field. I'd like to take it apart and put it back together and see if it'll work again. Basically, I'd do it with a bunch of different electronics.

For Tristan, hands on learning is motivational because projects allow more concrete concepts to be applied to the learning process rather than learning only abstract concepts. Tristan believes that projects allow people to comprehend difficult concepts. He describes this belief in the following way:

I'm a huge fan of hands on things and projects. You learn a lot from lectures and slideshows and those sorts of things, but I don't think you really . . . comprehend what you're doing until you actually put it into practice. You know, there's a lot of theoretical things, especially in mechanical engineering, and you know you learn about it and see the slides and you draw the graphs and makes the matrices and, you know, there are all sorts of things on paper. But, you don't actually really understand what it means until you can actually see what it does.

Additionally, Darian sees hands on learning as a context of extrinsic motivation at the identification level. It is through the extrinsic lens that Darian sees applications for projects. He assigns value to a project if he can see a purpose and articulate a benefit that comes from the project. Darian’s behavior seems to align with what Lombardi (2007) said about authentic based learners, “Learners look for connections: When we approach a subject for the first time, we immediately try to perceive the relevance of the new concept to our lived experience” (p. 8). In that vein, Darian shared that he needs to see this relevance in order to maintain motivation. In his words:

Well for me, I prefer hands on learning, I think that for me, that conveys . . . a sense of learning . . . because I actually get to hold the model, right. If I can see the application of it, I'm willing to learn more and more about it. But if I don’t see an end use for it, you know, I'm thinking like, well there's tons more out there that I could be learning, and applying my hands on knowledge to, compared to
something that I may never use . . . or I may never see the application for. And if I can see the use for it, I'm willing to learn more about it.

For Wendell, who has a natural interest in working with his hands, the motivation to learn is intrinsic and working with his hands ties into his interest in building something from the ground up. For Darian, who is motivated by the end results, the project has an obvious implication in preparing to work in a specific job. With hands on learning, which addresses both intrinsic motivation and extrinsic motivation, it is no wonder that every single person interviewed mentioned it as a major factor in being motivated to learn.

**Achieving Goal/Avoiding Failure**

A second context that was mentioned by every research participant was the concept of being extrinsically motivated at the introjected regulation level by the desire not to fail during the contest or by figuring out how to fix something that has failed with the engineering functions. Each of the participants spoke in some way about being motivated by some of their failures. Conroy and Elliot (2003) point out that “early motivation research identified the motive to avoid failure, or fear of failure (FF) as an energizing agent for human behaviour (Murray, 1938)” (p. 271). One of Murray’s contemporaries, who subsequently studied achievement motivation, was Atkinson (1957, 1964, 1966) whose theory of achievement motivation hypothesized that individuals are motivated by two purposes, either to achieve a goal or to avoid failing at a goal.

In terms of the Robosub competitors, they knew they could not achieve the goal of winning. So, they appeared to change their goal to one of saving face or avoiding failure. Chad discusses this concept, “I think it’s the more negative side of motivation as
in I don’t wanna fail.” Connor, too, spoke to the difference in this type of ego-based motivation when he was asked if there is a different level of motivation for not failing versus trying to win or achieve.

We didn’t wanna look like idiots. Because, again, the people at competition or from industry, and the people at RoboSub and RoboBoat in particular are the same people, the same people who run the boat competitions. So we didn’t wanna go to RoboSub and, you know, look like idiots and have that effect our reputation at RoboBoat. So, that was sort of our motivation. . . . We didn’t wanna look like idiots. We didn’t want our reputation to get hurt. We did just enough to not look like idiots. . . . If we thought we could have won, we probably would have been working on it more vigorously from, you know, in the beginning, but we didn’t.

Chad further drove home the differences between motivations when trying to achieve a goal of winning versus avoiding failure. Having competed in both competitions this past year, Chad shared the difference in motivation that came when there was some failure on the Roboboat team, which expected to win, versus the failure that occurred on the Robosub team that had no expectations of winning and were simply trying to avoid failure.

With boat, we had high expectations and when things didn’t work out at competition, we were . . . there in the moment and we would do anything to . . . push to win, and we learned a lot that way. With the competition at sub we tried some weird ways to kinda almost cheat the system, and when I say cheat the system, I mean it’s not in the spirit of the competition necessarily. . . . the spirit of an autonomous competition. This sub . . . we were able to get our points because we were able to finagle our way through the gate and kind of get lucky a little bit, you know. But we . . . still learned interesting things about how to do that, you know, how to finagle your way through. You’re still learning, it’s just a different kind of learning.

However, according to Chad, not everyone is capable of learning from failure at all times. Chad points out that in order to learn, you need the right mindset at the right moment:
When things have failed, people handle them very differently. There’s kind of a moment where you go, “Crap!” And then, immediately, I move on to what I can do next, or what you can do next ‘cause that’s how you have to approach things. I’ve seen other team members do quite the opposite and literally freeze up like start screaming. We had a [robo]plane, during a take-off, where one of the pitot tubes actually fell off and hit the motor, stalled the motor, and shut the plane off. So I take over the control of the plane, but the plane got damaged, it ripped the motor out, so it just dove and broke the plane.

I handled that by going, ‘Well, crap! This sucks.’ So I walked over there. I was like, ‘Okay, let’s find all the parts and let’s see why this happened.’ And, the same day I already had started building the next plane. So you push to 110%. Other team members, on the other hand, were really demotivated and just kinda wallowed in their own pity. We had one team member who starts screaming. Um, we had one team member who kinda... he was silent. He just sat there and myself and another team member—we’re picking up the parts and trying to figure out ‘cause we had no clue why. We figured out after by looking at the parts that were broken and saying, ‘Well, this is what happened.’ And, there’s a stark contrast between the two.

The motivation not to fail is not always about saving face. It can also motivate future learning and behavior. For example, when your favorite football team loses the Super Bowl, or your home baseball team loses in the World Series, one of the most common phrases is “just wait until next year.” This utterance is a perfect example of failure avoidance. Adam shared that he was motivated for future competitions by failure at his competition. “It was a little bit depressing with how you’re kind of struggling to have the vehicle go straight. Never again are we going to have that kind of failure.” Lewis agreed, when he shared that the motivation he acquired from failure would carry-on for the next year and for future years, “Because we had a system this year that was at a certain level, and we want to be at a higher level the next year. So it’s motivating, we definitely will get more work done this year.” From this motivation, Lewis believed that he and his teammates were able to learn the importance of being more organized and the
importance of testing the system each step of the way. These are both important lessons for any engineer.

Tristan saw failure avoidance similarly to Lewis and Adam—as a desire not to lose. He stated that he hated to lose even more than he likes winning. “I don't think anybody likes to see things fail. You know, in science and engineering, things fail. You know, sometimes it's okay. Just . . . do better the next time.” However, Tristan also pointed out that failure can be a great teacher, stating:

I know, especially after my freshman year, that was a, a huge thing for me. I was given some ability freshman year to build some things and, you know, at that point, pretty much not an engineer (laughs), so, um, so they're designing things and then I realized that the way I designed it just doesn't work. I mean, we can, we can physically build it, but then nobody could put wires in it and nobody can, you know, work with it because it's just unusable. And, I mean, anybody can learn from that I think.

Essentially, being motivated by failure was described by the participants in two different ways. There were four participants that described wanting to save face or to avoid looking incompetent, which aligns with Nicholls’ (1984) concept of ego as a motivator. These participants seem to share the characteristics of someone who fears looking like a failure. The second description of learning by failure comes from those who will not allow defeat. The second set of four participants describe striving to figure out why and how the answer continues to allude them, which also aligns well with the concept of ego motivation.

**Because of the Competition**

Six out of the eight participants mentioned that their motivation to learn was derived or at least enhanced based upon their desire to win a competition. Johnson and Johnson (1989, 1996) suggest that the competing groups would be more successful in
learning if they would cooperate instead of compete. Johnson and Johnson would suggest that if the competitors work together to share the workload and learn from each other’s successes and failures then learning would be optimized. However, what also is important to note is whether the participants would gain as much extrinsic motivation from a situation where there was no competition. At least according to five of the participants, the answer is no. In Adam, Chad, Connor, Lewis, and Wendell’s experiences, they shared that they would not be as motivated if it were not for the sense of competition. Connor shared that without competition there would still be interest but not nearly the amount of motivation.

It’s still the fun technical . . . challenge to try and figure out how to do it. But without the competition, why would I do it, you know? The benefits of the competition are really important, you know, being there . . . getting recognition for taking first place. Getting prize money is important. The benefits of the competition are really a big motivation to do that, and actually try to accomplish the technical aspects.

Wendell agreed with Connor’s sentiments about there being less motivation if you take away the competition. He also shared a specific example of when the monocopter was no longer a project for competition, there was less drive to work on it, even when it still held an interest.

It may be a little less motivational, but, um, since the project itself was interesting, I would still be willing to work on it. Like, there’s a couple of projects in our lab that don’t necessarily have a competition that we still work on, like the monocopter, for one. That’s one of the things that I still work on even though it used to be for the higher competition, but . . . now they really do get used, but I still work on it every once in a while. But, it does kind of get pushed to the back burner for something like the RoboBoat or one of the other competitions.
Likewise, Lewis doesn’t believe there would be the excitement or motivation for learning without the competition. His response indicates that without the competition he would have a lack of interest.

Because you’re given a task . . . each task has 5, 6 goals. You have to do this, then you can do this, and that way you can see, ‘Okay, I can’t do this. We don’t have the systems for that.’ So then you have to formulate a game plan of what to do. Without competition, there is no evaluation of what works, what doesn’t work . . . which isn’t as exciting.

Chad has a slightly different take on the importance of competition. For Chad, a competitive spirit is necessary in order for team members to persevere through the difficult lessons, failure, and other bumps in the road that come from learning via engineering design competitions. He expressed it this way:

Students can be really motivated to get you to win, but if they’re also not in it for the competition . . . they aren’t interested with . . . the win. That’s kind of demotivating I got to say. . . . Those people really get angry really quickly and they just start getting frustrated and they quit an idea and they’ll change ideas really quickly and not be . . . understanding . . . of people’s feelings because we pour our hearts and souls on these things.

While the participants were clear that competition provided them a sense of motivation, it is important to note that the competition they experienced was outside of their learning group or Robosub or Roboboat teams and not competition from within their teams. It is the competition from within or oppositional interaction that Johnson and Johnson (1996) warned against. Chief amongst Johnson and Johnson’s concerns was competition leading to individuals within the same team or within other teams discouraging or disrupting one another. From both my observations and the extensive interviews of who/what brought about motivation and who/what impeded motivation, there was no sign that either teammates or the competition ever acted to disrupt their
learning. Instead, the concept of winning during the competition, like avoiding failure, seems to imply motivation at the introjected regulation level.

**Hope That It Will Lead to a Job**

As was mentioned earlier, all eight participants described some portion of their motivation as occurring because they believed that participation in the competitions can help them obtain a benefit or meet a goal. For five participants, one of the goals that serves as a context is the hope of being able to obtain a job. Chad goes as far as to say that obtaining a job or starting his career is ultimately why he is involved in the competitions in the first place.

I mean ‘cause that’s what we’re here for. When it comes down to it, this is the . . . step in our lives that prepares us for that, and we will have a leg up on other people. Then when we go to find the job, we’ll have . . . a great opportunity and be able to advance quicker.

The participants’ descriptions of getting a job as a possible outcome and motivator is a clear example of the identification level of extrinsic motivation and seems similar to two motivation theories. The first is the aforementioned achievement theory. Atkinson’s (1966) achievement theory suggests that the participants are motivated to obtain a goal or avoid failure. The students who have made it a goal to obtain a job and feel that the engineering design competition is a path to that job are possibly motivated to learn so that they can impress the judges. The judges in turn may offer them employment. Connor describes this scenario in the following way:

The benefits of the competition are really important . . . All the people from industry that are there watching and . . . at the end, if you do good, they’ll offer you jobs and stuff.

The participants’ descriptions also have several characteristics to what Snyder (2000) called the hope theory. The hope theory states that if a person sets a goal that has
value to them, and that person has a reasonable belief that they can achieve that goal, they are more likely to stay motivated and persevere in achieving that goal.

Ultimately there was no one reason why students wanted to obtain a job or start their career. For some, it was a love of the industry. For others, it was something they have dreamed about since childhood. Still, for others it was an ends to a means for supporting those that they love. Regardless of why the participants want to achieve a job or start their career as the ultimate goal of the engineering competition, it still appears to serve as an extrinsic motivator to learn.

**In Authentic or “Real World” Situations**

Another context that brought about motivation for the Robosub and Roboboat competitors was when learning occurred within real world situations. According to Kearsley and Shneiderman (1998), real world learning must be authentic in nature. In order to be considered authentic, the project or learning environment needs to require a problem that challenges the learner and takes multiple disciplines to solve. Additionally, authentic based learning must actually create a sense that the learner is experiencing the same type of environment and learning the same type of lesson they would experience or need in the “real world.” This simulation of the real world was mentioned by several participants as one of the reasons that they felt a sense of motivation. Like in other contexts before this, real world scenarios are especially situated in the identification level of extrinsic motivation. Those competitors who felt they were motivated by authentic situations were also the same ones who felt that motivation to learn was needed in order to obtain a benefit or meet a goal. Darian, Connor, Lewis, and Tristan all shared their belief that real world scenarios led to motivation to learn. Tristan explained that he
thought that projects with a real world prospective were enjoyable and that he was more motivated to learn because it prepared him for later life.

I think these projects are very, very close to what, what I do in the real world. Uh, we have a budget; I have to manage the budget. I have to manage a team. We have to talk to suppliers, talk to manufacturers. We have to . . . do travel plans, and we have all these things that, you know, are real world that we're doing on a very small scale. And there aren't many of us, but, I think it's very, very close to what we're doing.

When he was asked if this keeps him motivated in some way, he shared that it is a “huge motivator.” He went on to share that the motivational aspect made him want to succeed. “And then . . . I want to be better at it because I want to be successful when I leave here.”

Lewis admitted that everything about the Robosub may not be a part of his future, but the competition had a number of transferable skills that he would use throughout his career as an engineer. According to Lewis, it was the knowledge that he would gain these transferable skills that helped to bring about motivation within him.

I probably won’t go into sub building after graduating college, but you can take the same computer systems and just change the code . . . And you can make that into a plane just by putting wings on it and making it wider. You can put wheels on it and then use the same motor controls, same navigation controls, same knowledge of how to build a frame and . . . now you have to have a car. I’m not entirely sure what I want to do after graduating college but definitely the systems we use on this RoboSub project and other robotic stuff [are] the same systems used in . . . actual real planes and real military purposes.

When Zane spoke about authentic scenarios, he shared that they taught him how to work in an engineering group. Zane went on to share that an engineering group would allow him to learn the skills necessary to be successful in his future work environment. Several of these skills include:

How to problem solve, . . . how to have a deadline, know how to . . . have real world experience, know to work with an actual group, working in a team in Physics lab isn’t the same as working with an actual engineering group they work
with for a year plus spending a ton of time with trying to reach an end goal or trying to reach a task whatever task that might be. In this particular case, it is . . . a robot . . . boat . . . but as soon as I graduate, hopefully, I’m going to be working with the group to produce something else—a spaceship, a plane, something.

Moreover, Connor believes that a student cannot gain this type of experience or its resulting motivation in a classroom. He thinks that these real world scenarios are unique learning experiences that cannot be duplicated and further believes someone cannot get this learning from anywhere else. For him, it’s very important to learn from the competitions, and he attributes this unique learning to why he is motivated to learn from the contests. In Connor’s words:

I mean, it’s the kind of stuff that . . . they don’t cover it in any of the classes. It’s the kind of stuff that unless you do it, you know, you’re not gonna completely learn in any other way. Our field is kind of a niche field. So, the things that we’re doing, most people don’t do when they get into their jobs. If you’re going into robotics . . . you have to have these skills that don’t really apply to most other positions. Like aerospace engineers go out and . . . design airplanes, and they sit at the computer all day nonstop. But with robotics, you actually get your hands on stuff. You’ve got to do soldering, wiring, and stuff like that. So it’s that kind of stuff that you don’t learn through other aspects. That’s a huge motivation to learn. It’s because I’m gonna use this later on. It’s gonna be important as I go into that field.

Darian agrees with Connor that an authentic experience can help to bring about learning and motivation to learn. However, unlike Connor, Darian believes that many of these skills can be learned in specialized classes. Darian explains this belief in the following way:

I took a class, Computational Heat Transfer and Fluid Dynamics, and in that class . . . there were no quizzes or tests, but it was more of . . . of something that you had experienced in the industry where they’re teaching you how to do things. For example, if you showed up to work at a new job site, they're not just going to hand you a project, they're going to give the necessary training, so it was more of a training-based class rather than learning-based. The professor shows you a few things here and there, and you experiment on your own. You figure out how to
work things, and then she gives you an assignment and she gets the gist . . . of how you're progressing. If there are issues with an assignment across the board, then she'll back up and show . . . that everybody makes this mistake and this is what you're supposed to do, kind of thing. So it's more of . . . a training based session rather than a very theoretical-based session.

Throughout the participants’ thick descriptions, they shared a desire to feel as if their learning was connected to a purpose and had a clear context to their future careers. Within their responses, four of the participants shared that real life scenarios provided them a clearer understanding of why they were being asked to learn a subject or concept. For these four students it seems that this clarity provides motivation to learn.

All four participants, who shared that these authentic experiences motivated them, ascribed that motivation to an extrinsic identification level domain, basing their motivation from real world scenarios on some benefit that they can gain, specifically a future job. However, there also seemed to be a sense that real world scenarios made the students feel as if they were truly engineers or prepared to be engineers. They seem to have internalized this experience and reflected on what this experience and learning means to their future and in doing so have embraced themselves as engineers, found enjoyment in the authentic situations, and were motivated to continue to learn. It is through this reflective action that the participants were also extrinsically motivated at the integrated regulated domain as well.

**Facing Deadlines**

Numerous motivation researchers such as Amabile, Dlejong, and Lepper (1976) and Deci, Vallerand, Pelletier, and Ryan (1991) have found that adding a deadline to a person that has an intrinsic reason to be motivated can significantly reduce the individual’s motivation. Yet there is also research into the positive effect of deadlines on
task performance (Ariely & Wertenbroch, 2002). The task performance research shows that both self-imposed and externally imposed deadlines assist in controlling procrastination and increase task performance. The argument could be made that when a deadline is established it sets up an achievement motivation situation (Atkinson, 1957, 1964, & 1966) where individuals would feel that they failed if they did not meet the deadline. While this deadline may weaken the motivation of someone who is trying to learn for learning sake, as is the case in an intrinsic motivation situation, it seems to extrinsically motivate at the introjected regulation level those trying to win or achieve a goal. Regardless of the effect that deadlines have on intrinsic motivation, several of the participants believe that deadlines are integral parts of their motivation. Chad, for instance, seems to believe a deadline is a motivator that helps the participants to accomplish their tasks, stating: “You’d be surprised at how much gets done because there’s a day that everything has to be done by. There’s definitely . . . a change when you start getting closer.”

Tristan also shares this belief so much that he actually advocates for even more deadlines. Deadlines in Tristan’s mind allow people to become more motivated and experience less procrastination. He shares this belief in the following way:

I still believe that we need to have . . . more deadlines. We've got . . . this one big target at the end of the year in June or July but . . . we tend to slack off a lot in the fall and then rush to get it all done in the spring and the summer. So we could probably learn more if we were driven to do it earlier.

Adam also advocated for more deadlines when he shared his belief that an engineering design team needs to work more consistently throughout the year rather than just at the very end of the year. “I think tighter schedules instead of just like, ‘Hey, can
you work on this so we can have it done by this summer’, because it’s such a long off goal.”

For the four participants that mentioned deadlines as a source of motivation, they described the need for a tangible finish line or due date. This sense of having to have things completed took away their willingness to procrastinate and, likely, works hand in hand with the earlier context of not wanting to look like a failure and the context of wanting to achieve a goal.

**Sense of Being Challenged**

What might have been the most surprising concept in this research was the student competitors’ comfort with being challenged. Conventional wisdom says students are looking for the path of least resistance. However, Adam, Connor, and Tristan seemed to disagree with that idea. For these particular students, being challenged is an important ingredient to being motivated to learn. Adam relayed this concept when he shared the story of his calculus three class, which ended up being much harder than he expected. Adam, the only co-researcher who appeared to be solely motivated extrinsically, saw challenges from an externally regulated extrinsic view point. In his words:

My first semester, I had pretty much one of my hardest classes I ever had, which was . . . calc 3, and it was an honors section. It was mostly just really wanting to do well, unlike on the first test, like going into it, I was like, ‘This shouldn’t be too hard’ and when I saw how hard it was and my grade, I was like, ‘Oh, this is not what I want’ . . . Basically, from there, I just put more and more time into it. And, then the semester after that I had the same professor for . . . differential equations and so I just put more and more effort into it.

Adam went on to say: “It was kind of a rise to the challenge sort of thing. See if you can do it.”
Tristan and Connor, however, see challenges from a different viewpoint. Where Adam is motivated from his extrinsic motivation, Tristan and Connor describe their motivation as being derived from challenges through an intrinsic lens. For them, being challenged is the opposite of being bored. Being challenged is an intellectual exercise and is something they do to learn more from a topic that they enjoy. Tristan explained the concept this way when he shared the following idea:

Things that are trivial . . . don't really motivate me in the least. But . . . I like to be challenged—that's most of the fun. I mean, the challenge is a major part of it . . . for engineers who like to solve problems. I took a class that was very challenging for me. It was project-based. You actually have to really learn. I mean, they're high-level things that normally, you know, you just don’t see in class. But . . . I was able to apply it and really get into it. And, I think I learned a lot from it, actually. I got an internship this summer for it because I was so excited about the topic.

Connor even goes as far as to say that he cannot be motivated by a project unless it is challenging. Connor was asked what he thought a project needs in order for it to motivate him to learn. His response was: “Challenge—it’s got to be challenging.”

Connor believes that enjoying challenges is built into his personality, sharing:

I like a challenge. I think it does take a certain type of personality to actually, you know, take that and use it to motivate them to learn. But the challenges of things are always interesting to me. I do the competitions because, they’re kinda stressful, and that’s . . . It’s exciting.

He went on to share that if the project is easy, then he is not as motivated:

Yeah . . . in my senior design class, we did a project that I’ve actually done in robotics my freshman year. It was just literally boring. Because . . . I mean, there were some new aspects of it, but it was just like, ‘Wow. This is pretty basic for me. I’ve been doing this for a while.’ So . . . I wasn’t as motivated. I kinda coasted through that class.

Two of the three participants seemed to describe being challenged in the same way a person might view solving a difficult puzzle that has no prize at the end. These
two participants appear to want to learn for the sheer desire to learn all they can to solve the challenge. However, the third participant, Adam, seemed to see a challenge as a competition and beating a challenge to be similar to receiving an award or an extrinsic prize.

**Who Helped Bring about Motivation for These Student Contestants?**

Each participant was asked to describe in detail any interaction with their other teammates, their advisor, coaches, or any other individual related to the Roboboot or Robosub competition that led to their motivation to learn. As can be seen from Table 4, the participants’ answers were varied on the “who” including: 1) teammates; 2) coaches/mentors; 3) the competition; and 4) family.

Table 4

*Those Who Helped Bring about Motivation*

<table>
<thead>
<tr>
<th>Name</th>
<th>Teammates</th>
<th>Coaches/Professors</th>
<th>The Competition</th>
<th>Family</th>
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<tbody>
<tr>
<td>Adam</td>
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<tr>
<td>Chad</td>
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<td>Connor</td>
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<td>Darian</td>
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<td>Lewis</td>
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<td>Tristan</td>
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<td>Wendell</td>
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<td>Zane</td>
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While four different individuals or groups were identified as “who” helped bring about motivation, there were reasons why people contributed to the participant’s feelings of being motivated to learn. These reasons ranged from being inspired by someone and wanting to emulate them to feeling that they could help them achieve a goal. While there
was not one consistent answer to “why” these individuals/groups brought about motivation, there was one reason that was described by participants on numerous occasions throughout their interviews. This reason may best be described by Roman philosopher, Marcus Tullius Cicero, in his work Pro Archia Poeta,

> We are motivated by a keen desire for praise, and the better a man is the more he is inspired by glory. The very philosophers themselves, even in those books which they write in contempt of glory, inscribe their names. (62 B.C.)

While not every contestant was seeking to impress each identified individual/group, at some point each participant discussed the importance of impressing someone and receiving that person’s praise, acceptance, respect, and/or recognition. Whether that sense of approval is from a parent, the admiration of a younger sibling, or a pat on the back from a professor, the participants’ descriptions seemed to correspond with Ryan and Deci’s (2000) concept of extrinsically motivation at the introjection regulation level where praise and recognition serve to assuage the ego.

This desire to be praised or thought of as the “competition hero” can be a potent motivator to learn, to take action, and to persist on with difficult challenges. However, in the same way that motivational theory researchers describe deadlines as detractors to intrinsic motivation, they also describe the pressure that individuals put on themselves when they are trying to impress others—or when they feel teammates are counting on them, coaches are expecting something from them, or family members anticipate particular results (Deci, Vallerand, Pelletier, & Ryan, 1991). Again, while the extrinsic awarding of praise might negatively influence the intrinsic motivation of the participant, it also seems to fuel the extrinsic motivation of that same participant. This desire to live up to their teammates’, coaches’, and families’ expectations seems to be rooted in a
desire to gain respect and praise, or to fulfill a sense of familial or team duty, which can be accomplished through helping the team to perform well during the competition.

In the next several pages, you will see how being inspired by individuals, the desire for praise, the need for respect, the need to care for the family, the desire to emulate, and other psychological, ego-based needs appear to be perpetuated by various individuals and/or groups. These individuals and groups, teammates, coaches/professors, family, and the competition itself make up the answer for “who” helped bring about individual motivation for these student contestants.

**Teammates**

The answer most often given to the question of who helped bring about motivation to learn was their teammates. It should be no surprise that teammates would look to each other to bring about motivation. As Tuckman (1965) pointed out, groups become dependent upon each other as early as the forming stage, and it is this dependency or the feeling that others are counting on them that participants listed as a sense of motivation that they gain from their teammates. Wendell, for instance, felt that he needed to learn to be a better coder because his team thought of him as a good coder, saying:

I'm known as one of the people in the lab who are good at programming, who knows what they're doing, who can get stuff done, so that definitely gives me more of a motivation to actually prove them right—that I am that type of person.

Wendell went on to give a specific example of how his teammates counting on him led him to take action and learn how to solve coding problems. Wendell expressed it this way:
One particular example would be during the Roboboat competition when we were first . . . having problems navigating through the buoys. We were trying to figure out what the problem was. This was before we found out about one of the motors being broken. The boat was . . . swiveling a lot. It was just not responding appropriately and then somebody basically said, ‘Well, if anybody can solve the problem, [Wendell] would be able to.’ So that actually gave me a lot of motivation, and over evening work time I taught myself a couple of different solutions. Then, the next morning when we were testing, it was good for the tests and we were navigating the buoy channel really well.

I learned . . . a little more about how my software was working. Then I went back and went through a couple of different things. Also, during solving that problem, I sat down with my advisor. We went through a couple of different things like . . . filters and stuff, some of the things that I didn't really necessarily know too well since that wasn't really part of any of my coursework, but some of the stuff that was stuff the advisor knew really well. So he suggested a bunch of different things and a lot of them ended up working out.

Another way that teammates can provide a sense of motivation is acting in a capacity as an inspiration for what the individual would like to achieve or for others.

Zane shares that he looks up to many of the team members and would like to emulate or be like these other teammates. Seeing that these teammates are able to learn how to engineer Roboboats and Robosubs gives Zane the motivation to do the same and to learn how to do the same. He stated:

You know, being the youngest member of the team, it was really nice or . . . moving to see where some of the other people were as far as intelligence. Real, like applicable, intelligence, I guess I would say. Where they knew how to make things work, how to . . . be more of an engineer than I was by a really, really long shot and that wasn't years in the classroom. It was years in the [robotics] lab. Because they figured out how to make things work in the real world or in our little version of it.

So that was motivating to see where they were, and I pictured a lot of the older people in the lab as . . . more of engineers. Because they're the closest thing that I've seen so far as what I want to be when I grow up—what I want to shoot for when I get out of college. There, the motivation would be like, ‘All right, that's what I'm going for.’ They've been here a couple of years. In a couple of years, I want to be better than they are and go that way.
Chad also shared that he was inspired and motivated by his teammates. He specifically mentioned Wendell, as an example. Chad shared that Wendell’s quiet demeanor and dedication were things that he was moved to emulate, and he felt Wendell provided a great example of what others should be like, stating:

I think I mentioned Wendell for being so steadfast and working so diligently and hard . . . on his program. That was very motivating. He is quiet . . . It’s a quiet motivation and it’s like I think it’s the same kind of things when you see a lot of people doing a lot of work on projects. It . . . makes me want to work hard. It also gives me confidence that they will succeed. It’s a blind confidence, to be honest with you, but I have the confidence that Wendell is going to produce something amazing and he did.

Chad went on to share that one of the problems with the Roboboat competition was that there was no one that served as that sense of inspiration as Wendell had for the Robosub competition. He felt that there was no one in whom he could put his faith or anyone that was serving as a motivation. In Chad’s words:

There was no person really pushing . . . There was no person . . . that I had faith that they would do really, really well in programming. So, when I got there, I’m building subsystems for things that . . . well. I was trying to do like subsystems, just make sure that some worked. But, it didn’t really matter because [even] if you’ve entered the code perfectly, they weren’t going to do anything, it was just not very motivating. Um, you definitely have that mentality of like, you know, . . . this doesn’t matter because this isn’t gonna work.

When the participants spoke about their teammates and how they affected motivation, it was not always how they helped to bring about positive motivation. There were several examples of how teammates can demotivate each other. These examples serve to make Deci, Vallerand, Pelletier, and Ryan’s (1991) point that when an extrinsic reward, such as the desire to win, is added to intrinsic motivation, it can have demotivating effects. Especially when the desire to win is so prevalent that one allows others to cause them pressure, one takes on unrealistic expectations, or one allows people
to annoy them for small or insignificant reasons. Tristan and Zane provided several examples of how teammates can have less than positive effects on one another. Tristan, for instance, finds it demotivating when teammates choose their own agenda over what is best for the project as a whole, saying:

And, you know, when they, they start trying to drive the way things are going . . . just to satisfy one part of our whole system that can be very de-motivational, especially when they start to . . . get their way. And, you know, you can see the others parts of the system falling apart because now they’re no longer being looked at or, you know, we're refocusing all on one section, and it's difficult to work on projects like that.

Equally, Zane believes that there can be communication issues and personality conflicts that come from people that don’t consider other people’s feelings. These poor social interactions cause a lack of motivation. Within Zane’s example are classic signs of what Tuckman (1965) described as storming or the “issues that polarize the group and boil down to the conflict over progression into the unknown” (p. 386). Also, within Zane’s example one can see that Zane at least has learned to trust his teammates and see past their curt retorts and stressed behaviors. This can be explained, at least to some degree, according to Tuckman’s (1965) norming phase. This is the phase of group dynamics where individuals let go of their resistance to leadership and teammates and instead choose to act in a manner that assist the group in the group’s success and sustainability. Zane expressed it in this way:

Within our little group, . . . we’re not the best at social interactions. Sometimes, as engineers, and . . . occasionally the most stressful part of these competitions is the other people. And me too, I mean, I’m in that group. Um, working with other people is . . . occasionally the most stressful part. Uh, demotivating as far as the . . . new guy in the lab is not seeing things for what they were as . . . stressed out engineers trying to get the goal accomplished.

And instead of looking at it how I would now, it’s just like, ‘All right, keep going.’ It was occasionally demotivating to see . . . [and] to be shot down by the
students in a very blunt manner when... you look back at it or when you look at it detached. It was... a good call. But again, it was a good reason. The reasoning behind saying certain things were correct or like shooting down these ideas are correct but, as far as social interactions go, occasionally were not that great at it. So in the moment it was very demotivating to be shot down.

Zane also shared that sometimes teammates just won’t get along:

And, of course... some people just don’t work together very well or you don’t get along that great. That’s just normal. I personally don’t work that well with another student in the lab. He gets on my nerves. That’s, that’s an easy way to put it. He... has a lot of experience and has a lot of knowledge... and I know that he’s done a lot in the past, but... last year he didn’t really do a whole lot... It was frustrating to me... to have a conflict with a person and not hold them in highest respect as I do other people in the lab. So then that made it harder for me to continue to work with him as well as I’d liked it to. There was just occasionally arrogance and everything was gritting, I’ll put it that way.

For Zane, this is perfectly normal but still causes a difficult dynamic and a cause for demotivation.

The eight participants described both positive and negative ways in which their teammates effected their motivation. The positive experiences with their teammates included times when the participants were trying to live up to their teammate’s expectations, such as being a good mechanic because the teammates lauded them as amazing mechanics. Secondly, the participants were motivated by teammates when their colleagues were serving as a source of inspiration and a model of how to act. However, several participants did share that there were interactions that caused motivation to wane such as when teammates were being selfish or when trust was in question.

Advisor/Mentor

In addition to their teammates, the participants also identified the faculty mentor or their competition advisor as someone who helps bring about motivation to learn. Within each of the participants’ explanation as to why they were motivated by
their advisor, their responses are reminiscent of Sanford’s theory (1966, 1967) which contends that learning occurs when there is an appropriate balance or level of challenge and support. The participants in this study also saw the importance of the challenge and support relationship. Connor, Wendell, and Chad each shared a form of Sanford’s concepts of challenge and support when they explained that their motivation was encouraged by their advisor. Wendell explained his motivation from advisors in the following way:

Our advisor, one of the things that he does is . . . he likes to shoot down your ideas. And, he does that so that it makes you have to do the research so you won't just come up to him with like a half-baked idea, something that may or may not work. He actually wants you to sift through, work through the problem. Actually try to do any sort of math or do any sort of proof to see if your idea is going to work or do even for something like for software, which is easier to do than hardware, to actually try out and, uh, show him that's working and then to be able to get his approval on that.

Our advisor, he'll never tell you that we're doing it this way or one particular way. What he'll do is, if you come to him with an idea, he'll give you suggestions like, 'This is what has worked in the past or what hasn't worked.' And, also, he'll tell you why it may or may not work and then, if you're really sure that your idea is going to work, he'll help sit down with you and try to prove whether or not it's going to work—so working through your problem with you.

Tristan shared a similar response to Wendell when he described why he felt that the advisor helped to bring about learning, and how his interactions with his advisors led to motivation to learn. Tristan emphasized the important role they served, saying:

Our faculty advisors are actually quite hands off. They're very supportive of us. They'll try to get us . . . the parts we need if . . . there's something that's outside of our reach or anything like that. And, they'll actually . . . challenge us a lot of the times. We'll come up with an idea of something we want to do, and they'll sit there and they'll try to, you know, pull it apart and make us think about it. They're teaching us to, you know, think of our ideas, really flesh them out beforehand. When I go talk to one of our two advisors, I really need my ducks in a row. Because they're going to, they're going to ask me all the hard questions and make sure I've . . . really thought of everything . . . before we spend some money or try to make something or spend some time doing something.
When Tristan was asked of a specific example, he laughed and shared the following story:

Last year, I came up with this new idea for a boat we wanted to make. We weren't happy with the previous one we had. And, we went up to him and we pitched this idea, and he pretty much said ‘No’ (laughs). And . . . we're like, ‘Oh, it'll work. It'll be fine. It'll be fine.’ And, he, he said, ‘You know, do all your research. Show me what you can do and then maybe.’ So we know, especially from past experience, that if we can get an idea structured enough and it's . . . thought out enough, he'll at least give us a shot.

And we've done crazy things like monicopters before (laughs), which he doesn't think would be able to fly. So, we knew that we had a chance and so it was very motivational—motivational to go out and try to learn more about, you know. . . . We had this great idea and things we want to do, but, uh, we had to learn. We had to learn all about different subsystems and how they all work together and how many are going to control them and, you know, what kind of maintenance we're going to need on them and that sort of thing. And then come back to him with that and he let us do it.

Perhaps the most overt description of a participant being motivated by challenge and support came from Chad’s story of being motivated by his advisor, which he described in this way:

Our advisor has . . . this innate ability to motivate you. When . . . he does, . . . he has the perfect balance of like . . . negative and positive reinforcement . . . and it's really because he says them at the same time. We joke around and we call him “Dr. Coach.” Like he is cool. . . . He advises boat and the sub or the boat, not so much the sub, and that’s the kind of motivation you get.

Also described in the participants’ stories of how their advisors helped to bring about motivation was the concept espoused by Hamrick et al. (2002) when they pointed out that too much challenge would cause a retention problem within the group and that not enough challenge would stagnate learning. When asked what the threshold is between challenging and too difficult, Connor shared that it is hard to define and really is something that you have to experience, responding:
(Sighs) that's, that's tough. Um, I think, I think that's one of those things you kind of just run into. Um, I mean I've worked on projects where I probably spent two weeks trying to solve one thing and, you know, eventually sometimes you get it. But . . . that's not motivating.

In addition to being motivated through being challenged by their advisors, Wendell and Connor also shared that they were motivated to learn in order to impress their advisors. Wendell shared that he felt his advisors were so engaged that they would know when he was struggling and when he was succeeding, and that involvement made him want to impress them by showing his and his team’s competence. Wendell expressed it in this way:

I feel like our professors, always like checking on us. It makes me want to basically be able to show them that we're able to get this done, be able to do well in the competition.

Connor shared that it is the reputation of his advisor that motivates him to learn. He sees that impressing his advisor will help him to obtain a job in the future. He shared that his advisor is so world-renowned in robotics that if he could just impress his advisor, he could possibly get his advisor to recommend him for jobs. Perhaps, he could even introduce him to the right people. In Connor’s own words:

We go to this conference every year. It’s just like, person after person comes by, ‘Hey. Is your advisor around?’ And, you know, everybody knows him. He’s very well-known, very well-connected, and very well-liked. So one of the things that really motivated me, the reason I came to Embry Riddle in the first place, was because of my advisor. It was like, you know, you can get involved in these projects, and I wanted to work with him and impress him, cuz I knew that he could get me a job [laughs]. I knew that the benefits of knowing him were gonna help me out in the long run. Uh, he’s probably the person that’s motivated me the most over the years.

He doesn’t really do anything. It’s more of that I want to impress him, I guess. It’s I wanna . . . I want him to think highly of me, so that, um, you know, he’ll introduce me to his friends in [the] industry . . . and then I can be well-connected in the future, the networking aspect of it. He doesn’t really do anything. It’s just . . . I mean, he’s one of those professors that’s excited about it. He loves
this kind of work, and he’s really motivated to do it. It’s funny whenever his wife’s not in town, whenever she’s travelling, you’ll find him in the lab, hanging out until eight or nine at night. He’ll come in on the weekends if she’s not home. But if she is in town, he has to go home.

While nearly every participant spoke about the positive experience of working with his advisor, not every experience shared about a faculty member was positive. In fact, there were a number of stories that explained how a faculty member can have an adverse effect on motivation.

Darian, for example, shared that there had been a number of occasions where he faced plenty of challenge but little to no support. Darian’s experience was one where he felt faculty members refused to help guide him in the learning process, explaining:

I’ve had plenty of experiences where . . . well, not so much refused blatantly, but avoided trying to help me out. You know, they're like, ‘Well, you know, you go figure it out and come back to me when you have the answers.’ You know, I struggled a lot in my first semester of my junior year, you know. I had a class where, when the professor used to write on the board, half [of the] equation was on the right side, half was on the left side.

And, I couldn’t make sense of the notes and, you know, once again I was trying to copy the notes, and the professor was just going on and on. And we ended up . . . it was a Monday, it was a Friday class, and he was too involved with research, so he decided to cancel Friday classes. Uh, and that took time away from my learning.

You know . . . I was okay with him cancelling Friday classes as long as we made up for it, you know, the 15 minutes each . . . or 30 minutes each Monday and Wednesday. If you made up that, that would give that hour on a Friday. But instead, we only made up 15 minutes because he was more focused on his personal gain rather than the gain of a student.

For Connor, demotivation was tied to his dislike of a professor and what he perceived as a negative attitude on the professor’s part, responding:

I had a professor that was just kind of obnoxious. I didn’t like the professor. Um, didn’t like their attitude or their personality, whatever it was. And I was just completely turned off by that class. I was just not interested in doing any work or listening to what the professor had to say. The personality of the professor, I think, is huge. Because we have the professors that are really energetic and
excited about the topic, and the professors that are just kind of the . . . um, [laughs] . . . I think that makes a huge difference.

Connor also shared examples of times where he has seen faculty advisors demotivate their students. For Connor, anytime a faculty member takes over a project and begins to make decisions on behalf of the team, that faculty member would cause Connor to become disinterested and demotivated. In his words:

I’ve seen teams where the advisors doing some small things. That wouldn’t be a big deal. But I’ve also seen teams where the advisor is dictating every aspect of the design . . . at competition. At RoboBoat, I went over to another team and I was asking questions, and the advisor was like, “Well, we did it this way because this . . . ” And, it was very obvious to me that the students didn’t make the decisions. They weren’t going through the engineering process. They weren’t doing, you know . . . it to learn. It was the advisor saying, “Yeah. We’re gonna do it this way. We’re gonna do it that way.” And, that would be hugely de-motivational for me. If I can’t figure it out for myself and . . . try to do it myself, then what’s the point?

Connor related that with an advisor who micromanages a project, for him, there is a distinct lack of learning. He believes that there would be some learning, but that the learning could not be as rich as having the autonomy to succeed or fail on their own.

Connor went on to say:

Definitely wouldn’t learn as much. Uh, I’d learn the very specific things that the professor was telling me, but I wouldn’t think like, “Well, this is one way to do it, but there’s also this other way to do it, and I should figure out which one’s better.” Right? Because that way, I have to learn both techniques . . . and figure out which one is gonna be better for our application.

In summary, six of the eight participants described their faculty mentors as a source of learning motivation or as being a possible deterrent to motivation. One way that the participants described the faculty perpetuating motivation was when faculty both challenged and supported them and other participants. Several other participants
described their desires and attempts to impress their faculty mentors as a motivator.

Finally, a number of participants described faculty as having the ability to derail their motivation if they utilized teacher-centered tactics such as dictating how and what the students should learn or how the students should design solutions for the competitions.

**Other Teams’ Competitors**

As stated by the participants, the actual act of competing also was a context for motivation. Moreover, both Zane and Darian acknowledged the other team’s competitors were instrumental in bringing about motivation for them. Zane pointed out that within the competition, teams often cooperate and assist one another as they compete to try and be the best and to impress each other. About this, he remarked:

> When you go to these competitions, . . . at least my experience has been that we're not competing against other teams at all. We go there, and . . . something breaks or whatever. We help out other teams and say, ‘Hey, how did you do this?’ We tell them, ‘Oh, we did it this way.’ ‘Oh, that's a good idea.’ We go back and forth like that—learn from their teams. We're not competing against them. We're competing against the competition itself. Um, we're trying to beat the competition.

Darian also spoke about the other team’s competitors as friends. He shared that comparing and judging his own success to that of the other teams gave him a push or a motivation. In addition, Darian suggested that other individuals involved in the planning and judging of the competition also provide a sense of motivation to learn, stating:

> You get an opportunity to see where other schools are compared to you, uh technology-wise, uh knowledge-wise, and experience-wise. See what they bring to the table, see what ideas they have that you could have implemented. See what ideas that you have that they didn’t think of. See what works for them; see what didn’t work for them. It also gives you an opportunity to network with people. You know, the people that show up at these competitions . . . do this for a living. So when they say, ‘Have a piece of advice.’ It might be something you want to consider.
So, for me, it's ... motivation to go out there and experience something different from your university's academic environment. There's just a collaboration of all the universities individually, you know, showing up to compete their teams. But you see how the dynamic of different universities is. Some universities, they've been friends, uh, for a long time, and they become a team. For other universities, we end up just working on a project and then becoming friends.

Adam, Darian, and Zane’s descriptions of being motivated by their competition have similarities to two parts of Johnson and Johnson’s (1996) studies of those groups who engage in promotive interactions. While Johnson and Johnson saw three advantages to cooperation in learning: 1) achievement, 2) positive interpersonal relationships, and 3) psychological health, Adam, Darian, and Zane seem to describe two of these advantages achievement and positive interpersonal relationships in their descriptions of their experiences with competition.

**Family**

Several participants felt people outside the competition were motivation catalysts for more than just their ability to deliver praise. For participants like Darian and Wendell, doing well for the competition meant learning and learning meant being prepared for an important career. An important career meant that they could support their families, friends, and other loved ones. Being able to support their loved ones and friends became another sense of motivation.

For Wendell, this desire to take care of someone comes from the example that his mother set as he was growing up. Wendell discussed that if it were not for his mother and her sacrifices he would not be in school, sharing:

> It was a hard time growing up. I did not have the best childhood. So basically, I want to get good grades to be able to get a good job to help support her, uh, basically help give her money like she supported me.
When asked how often the thought of being able to support his mother like she supported him brought about motivation to learn, Wendell shared that it was a significant amount.

“Uh, quite a bit. I mean, especially during the harder courses. I'm always thinking about her and I talk to her at least a couple times a week. So that helps.”

Darian had a similar take on the importance of personal relationships and being there for family. Rather than his mom, Darian shared the importance of being available for his sister and nephew as well as his mentors, professors, and co-workers. During one of our interviews, Darian disclosed:

My family . . . it's because of them I'm here, where I am today. They have been the backbone of me through my hard times and through my great times. And it's because of them . . . I continue to do these things. Especially my little nephew, you know, he looks up to me. My sister is a single parent so I played that father role for him. He loves planes. . . . I just so happened to be at an aeronautical school. And that kind of, you know, continues my motivation to learn, uh, from a personal perspective.

You know, in fact, I brought [pictures of] people who have inspired me from a professional . . . university standpoint, you know. You have the Chair, our advisor, and you have another professor that really encourages learning. That’s because of him that I continue to believe in the fact that professors are here for the betterment of a student. Not for their own personal gains, because he's taking the time to invest in my personal and professional success.

I also brought this [picture]. This is one of the people that I work in the department with and she's one of the reasons that I'm still here today. You know, after I . . . graduated, um, I had a hard time letting go of this person. You know, she really imparted a very . . . personal knowledge and professional experience unto me and . . . I wasn’t ready to say ‘Bye’ to this person. So, you know, that person has inspired me to continue on my graduate work.

For my family, it's more that they can be proud of me. You know, uh, for these professors and mentors and advisors that I have on at the university, it's more of something that I see in them that makes me want to be like them. You know, uh, the successes that they’ve had, the failures that they have. You know, learn from their successes, you know. Learn from their failures. Um, so it's not so much to make them proud, you know, because . . . I'm not the only student that they cause these, uh, effects to, you know. I want to be in that position one day, regardless if it's in an environment, uh, academia or in the industry. I want to have the successes that they’ve had and I want to learn from the failures that they’ve had.
And you know, they . . . obviously have inspired me. So I want to pass it on to some other generation of students. I want to inspire someone else, uh, you know, kind of perpetuate the cycle.

For two of the study’s participants, their motivation to learn is reinforced by their desire to give back to their family. These participants relayed their belief that because of a deep connection and sense of duty to their loved ones they are propelled to learn and gain skills that will lead to a high paying job. The reason for wanting a high paying job was so that they could then take care of their loved ones. Darian had a second reason for being motivated by family, which was wanting to learn and be successful so that he could impress his nephew and then serve as a mentor to his sister’s young son.

**In What Ways Does This Motivation Propel Them to Act, Learn, or Achieve?**

In order to fully share the participants’ stories, it is essential that a final question is answered, which goes beyond why, how, when, and by whom the participants are motivated, and asks what action this motivation brings about. During our conversations, the participants described three distinct types of activities that were derived from their motivation to learn and their experience with engineering design competitions. The three activities that the participants shared reflect some of the understanding and results from classic learning and/or motivational research. The first activity described was derived by participants Chad, Connor, Darian, Wendell, and Zane’s interest in the subject matter and their desire to understand the subject better. Because of their intrinsic motivation, these participants were propelled to utilize self-directed learning. The second activity is not easily defined. It amounts to any action that will lead to the participants being competitive in the competition. For instance, Connor describes meeting competition deadlines. Lewis describes attempting to win the competition through tenacity, and
Adam shares doing extra research in order to win the competition. The final way that the participants’ motivation propelled them to act, learn, or achieve was derived from their desire to achieve employment. The final act was to obtain skills which will prepare them to be a possible candidate for future work.

Table 5

*Acts, Learning, and Achievements Derived from the Participants’ Motivation*

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<th>Self-Directed Learning</th>
<th>Obtain skills for a future career</th>
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**Being Competitive**

One activity that was promoted by the participants was focusing on learning in order to win the competition or obtain a job. One example of an act that the participants believe is a way to be competitive is to become hyper-focused on learning. Lewin (1951) and Mook (2004) shared that individuals who are motivated by an extrinsic motivator such as a deadline or a desire to win can find that they have figurative blinders on and that they become hyper-focused. When Connor shared how he felt deadlines affected his motivation, he seemed to be describing motivation exactly as Lewin (1951) and Mook (2004) described life space and how Csikszentmihalyi (1990) described the concept of flow, which is an experience where someone is fully involved and absorbed in
what one does. Connor described that when he is working on the robotics nothing disturbs him or can distract from his focus. In our discussion, Connor shared how he needed to focus on building an engine or writing code. During situations like these, Mook (2004) contends that the competitor’s life shrinks down or that the competitor has blinders on in an attempt to get the task accomplished. Connor describes a very similar experience:

A lot of my friends get mad with me because I won’t come outside over the summer, because I was in the lab all day, every day. They’re like, ‘Hey. We’re going out this weekend,’ and I’m like, ‘No. I got stuff to do.’ So, yeah, there’s no outside world. Yeah. I ignored a lot of text messages and emails over the summer, because I was just . . . focused on what I was doing.

I get excited about the project. The competition is coming up, and there’s things either going right or going wrong. And I just wanna be there to make sure that everything’s working the way they’re supposed to. So I . . . forget about the outside world. I go to the lab first thing in the morning, I go home, and then I go back to bed, and then come back the next morning. So, . . . yeah, there’s nothing else outside the lab, you know. We’re on that time crunch when we’re two weeks away from competition. When we’re one week away from competition, it’s like, I’m just . . . I’m there.

Another example of an act that the participants listed as a way to be competitive is to become tenacious about learning and work diligently to accomplish the task at hand.

For instance, Lewis shared that he learns from a desire to make things work, stating:

In the competition you need to make it work. In classes it is like memorizing the three techniques, whereas competition is like, ‘Okay, I have these three techniques. Which one will actually work?’ And it’s moving to try them out and then see, ‘Now, okay, I have tried these two techniques. Now I’m going to try this one.’ And then . . . you try something else . . . and again . . . again and again.

A final example of an act that the participants listed as a way to be competitive was explained by Adam, who expressed how he would do anything to win. This desire to win leads Adam to go the extra mile to do research and learn. Adam explains this philosophy in the following way:
[Wanting to win] motivates you to put a larger quantity of effort into it because with classes, it’s kind of just get the next thing done. Even if . . . you’re very motivated in it, you’re not really going to like go out and look up the history of it or other things about it. But, with the competition, you’re . . . going to look up more. You’re going to do research on different methods. For say like propulsion, you could say like, ‘Okay, think of where to mount thrusters.’ Or like maybe you don’t like the idea of just using thrusters so you want to look at different ways to like thruster vectoring.

Fundamentally, six of the eight participants who were motivated extrinsically found that this extrinsic motivation propelled or moved them to act in ways that would allow them to be competitive in the engineering design competition. Actual acts included working tenaciously or tirelessly at the project until they found a solution and being hyper-focused on the activity or being enveloped in the project with little knowledge of the outside world.

**Self-Directed Learning**

For those participants that defined their motivation as learning for the shear interest in learning and for a love of the subject, their intrinsic motivation led them to self-directed learning. Zane’s descriptions of acts that came from his motivation include several characteristics of a classic definition of self-directed learning. Zane described this motivation as leading him to self-discovery and learning on his own. He went on to share that self-directed learning led to a better understanding of the topic than out-of-context learning, which is typically taught in the traditional classroom setting. In Zane’s own words:

You have to teach yourself to learn . . . from the other people or professors or teach yourself from zero knowledge to being able to be the lead programmer in the group by the end of the year, [which] is where I went from. So, I think what it is, is you learn more . . . because in the classes you learn more out-of-context.
Wendell also demonstrated that his motivation led to self-directed learning. For Wendell, it was in order to understand watercrafts and software design, both of which he shared were useful skills that he was excited to learn based on his interest in the subject. When listening to Wendell, it became obvious that the self-directed learning that comes from his intrinsic motivation took away the “effort” that is present in classroom learning. Instead, there seemed to be a sense of desire to learn as he expressed himself in these terms:

I learned quite a bit. . . . I learned . . . how small boats work, how they perform in the water. I learned a lot more about programming and doing software for different types of hardware. The main drive to learn that is that it was an interesting project, something I was really interested in learning how to do.

In describing the drawbacks of faculty-centered learning and the need for self-directed learning, Knowles (1980) shared that adults tend to resist learning from rote memorization. In other words, they generally resist learning from lectures, quizzes, and exams. Instead, Knowles pointed out that an experiential learning style would be a better path for adult learners. No one might have better explained Knowles’ thinking on faculty-centered learning and the need for self-directed learning better than Darian when he shared his thoughts on how he was motivated to learn while helping to write the proposal for another engineering design competition, the EcoCar III. Darian explains his thoughts in the following manner:

For me, academic environment tests tend to be very stressful, and when they put the word test out there, I personally don’t like to take tests. . . . I can understand the material when it comes time to . . . but regurgitating it . . . in a certain standardized format, I have problems with that. So I tend to excel better in classes that . . . don’t have tests or quizzes, but it's more of your performance-based classes.

We were writing the proposal for EcoCar III. . . . It's not really a formal lecture base, you know. It's just the professor and [we] all sit down in a
conference-style, and we talk about what needs to be done. . . . The professor is not up there, you know, writing notes on the board and teaching. We are all in the same boat. We all need to figure it out together. The professor has not done this before either.

So it's . . . a very informal style. It's . . . the professor is learning at the same time we are learning as well, so it's an area of mutual respect.

Knowles (1975) would suggest that the participants’ motivation lead them to figure out what they needed to learn and then to formulate a plan for how to learn the needed skills and lessons. Those participants who discussed self-directed learning described many of the traits of Knowles’ concept of andragogy and self-directed learning.

**Skills for Future Career**

As was mentioned earlier, several participants believe that they can reasonably have hope that their performance during the engineering design competition could lead to career offers. This belief, at least in part, allows them to stay motivated to learn and to stay resilient in that learning. In addition, this belief that they might obtain a job seems to motivate the participants to take action to acquire skills that could be used in that future career position. Chad, for instance, was able to list numerous examples of future career skills that he was motivated to learn based upon his belief that the result of the competitions would be future employment.

In describing his role during both competitions, Chad shared that he learned to be a decision-maker and that he would be able to use these skills in his future career, stating:

So, it was motivating to be a part of the team and have those decision-making processes and also be the . . . go to for, you know, any . . . projects. It was kind of almost a responsibility. It was motivating . . . really seeing the system come together. I . . . had a subsystem, but it was still very motivating. . . . I worked on that subsystem. . . . I also worked on both, mechanically, and I didn’t really do much software. But, it was definitely motivating to see the things come together and have to come for these ideas and come up with solutions. Really, I think that was the biggest thing . . . pushing towards solutions to the problems that we’re having.
Like Chad, Connor saw himself as if he was already working in the field. He saw the competition as a simulation of a work experience. Where his teammates saw their role from an engineering perspective, Connor saw his role more like a project manager, expressing it in this way:

I’m usually focused on the sort of systems level engineering—making sure that all the pieces are coming together. Because I’ve got a guy working on the Nerf® turret, I’ve got a guy working on the thrusters and the control. But then connecting everything together is, for me, the challenge, the hard part, . . . And that’s what I’m really focused on, is trying to make sure that all of these people . . . are working together. And that’s where the project management comes in.

That’s huge in these competitions, because you have to know who’s on your team, what they’re capable of doing, and you have to assign tasks accordingly. And that’s, actually, always a really big problem for our projects . . . is having the people who can actually manage the other people and assign tasks. That’s something I’ve been trying to do for the last few years, and I think we’re doing okay now.

Connor also shared that beyond the engineering skills that can be developed, there are also large human resources aspects of the competitions that can be learned from anyone willing to take on a leadership role within the competitions. When Connor was asked why the human resources aspect of the competition was important to someone who was striving to become an engineer, he offered the following thoughts:

I don’t wanna be a low-level engineer forever. I wanna be a project manager and stuff like that in the future. So, it will help me get up in the industry. There’s actually a whole set of field of study in human resources in how to manage. So, being able to . . . understand that there’s a lot more out there that you need to understand if you’re gonna go to that next level.

The human resources and project management skills were not the only lessons that Connor described. Even after 20 competitions, Connor was still able to gain new engineering skills, expressing himself in this way:
I learned a lot of technical stuff. Going through the exercises of trying to make this work, how to connect, you know, a Nerf® gun to a computer, and make the computer shoot the Nerf® gun, um, a lot of technical things that I’ve never done before that were interesting and fun to do.

Tristan also acknowledged how much he has learned based upon his experience with the engineering design competition. Like Connor, he could articulate how much he had learned from both an engineering perspective and from a potential work-related perspective. Tristan also felt this experience gave him an advantage in the job market, stating:

I've actually done, you know, the physical work. I've done, you know, the math, the physics, the actual manufacturing. Then I've also . . . dealt with suppliers. Um, I've dealt with other groups internally trying to get things done. We give presentations to write papers. A lot of things we're going to do [in our career] is write papers and proposals and that sort of thing. And, uh, I've written a bunch of proposals. And every year we write at least one journal paper or journal quality paper published through AUVSI, not through a journal. But, um, I think all that stuff's definitely going to help me out.

Finally, Darian provided a specific example of how learning a certain task, how to calculate waypoints in the competition, will lead him to be able to understand that skill when he is at future competitions or when he is working in the future. Darian’s example is one more way that participants who were motivated by the possibility of a future career took action to learn:

Well if . . . in the future we encountered the same problem, I'll know that . . . I'll be prepared. You know, that using the GPS Waypoint at a further distance will be better compared to using the GPS Waypoint closer. And I'll pass that knowledge on to people . . . as it applies to competitions or just in everyday scenario where we are working on the system [and] it doesn’t work for example. If I get a job in the industry, if we ever run into . . . a situation where we are using GPS Waypoints, I can feed off of that experience or that learning that I had at the competition and talk about that.
Quintessentially, the four participants who identified building career skills as an act derived from their motivation believed that the engineering design competition motivated them because it closely resembled or approximated their future careers. In approximating their future careers, the experience contained aspects of the job that the participants believe will be useful in their future work life. Being aware that the experience contained actual skills propelled or inspired these four participants to learn the skills that could come from the engineering competition.

**Summary**

The preceding chapter provides the eight participants of the Roboboot and Robosub engineering design competition an avenue to share their thick descriptive accounts of their experience with learning motivation. Once these descriptions were analyzed, themes emerged which conveyed the student’s needs, including but not limited to hands on experiences, engaged professors, self-directed learning, engagement with their peers, and a need for both challenge and support. Throughout this chapter, the participants’ distinctive accounts serve as colorful tiles in a mosaic so that when the tiles are placed together, the eight participants’ explanations create a narrative which conveys what being motivated to learn means from their perspective.
CHAPTER 6

SUMMARY, RECOMMENDATIONS, AND REFLECTIONS

“She generally gave herself very good advice, (though she very seldom followed it).”

— Lewis Carroll

Like Lewis Carroll’s quote from Alice in Wonderland, those in higher education often give ourselves very good advice that we seldom follow. For years, education researchers such as Montessori (1912), Freire (1970), Knowles (1980), and many others have argued that “chalk and talk” as pedagogy does not provide the desired educational effect that our students, employers, community and, frankly ourselves as educators, wish to achieve. Yet as Mills and Treagust (2003) point out, in engineering, we still utilize lecture-based education as our main source of teaching. In maintaining this practice, we are perpetuating a process that seems to promote shallow learning (Bransford, Brown, & Cocking, 2000). It also fails to: a) motivate learning; b) promote confidence in the learner’s abilities; and 3) promote enthusiasm to learn, according to Wimer, 2002.

This chapter provides a summary of this phenomenological study of motivation as experienced by engineering design competitors at a selective engineering university. The chapter includes recommendations for future research, suggestions to educators for how to better understand and use engineering competitions in a way that will motivate their students to learn, and contains personal reflections on the research conducted. The audiences for this study are: 1) higher education faculty who are involved in coaching engineering design competitions or otherwise utilizing engineering design competitions as an andragogical tool in engineering and other STEM related fields; 2) administrators who, through their role in higher education, can influence the budget or the policies and
procedures that effect engineering design competitions; and 3) student affairs and other university staff that can influence and encourage student participation in an engineering design competition.

In order to explore motivation and an alternative way of teaching engineering students, eight participants were invited to share their experience of learning and being motivated to learn engineering design concepts as they prepared for and competed in the International Robosub and the International Roboboat engineering design competitions. Through the description of their experiences, the participants shared thoughts on motivation and ascribed personal meaning. The participants also shared in what context motivation occurred for them while preparing for and participating in the competitions. The participants’ descriptions included insight into who helped bring about motivation to learn. Finally, the descriptions included discussions into ways the motivation propelled them to act, learn, and achieve.

**How Do Student Contestants Describe Their Motivation and Ascribe Meaning to It Personally?**

The participant’s descriptions of their lived experiences seemed to confirm what Deci (1995) suggested—motivation can be described as either intrinsic or extrinsic motivation or a combination of both. Seven of eight participants, all but Adam, described a portion of their motivation as intrinsic in nature. They each shared that they were internally inspired with a desire to learn the subject. They described this intrinsic motivation as an interest in the subject that gave them a desire to understand the subject better, or as Zane, one of the participants, put it “a combination of curiosity and . . . the joy of learning.” Likewise, Wendell and others spoke about this internal motivation as
something that they have had since they were very young, stating that engineering and building things with their hands has been something they have loved from the time they were playing with Legos™. According to the seven participants who defined their motivation as intrinsic in combination with extrinsic motivational factors, engineering design competitions provide a valuable experience that perpetuates their desire to learn the subject. For them, the competition holds mysteries that need to be solved. As the students are inspired by the subject and challenged by the mystery, they appeared to become further motivated to learn, research, and explore more about the subject.

All eight participants identified extrinsic motivation factors. When it came to extrinsic motivation, they were motivated by rewards and/or punishment avoidance. For six participants, they described their extrinsic motivation as feeling that if they worked hard and spent time learning the needed engineering components, then they would be able to obtain a benefit or meet a goal because of understanding the subject better. Colloquially, this is known as motivation by “carrot and stick.” For many, such as Connor, the carrot was the idea that doing well in the competition perhaps would result in a job offer after his master’s program. A second carrot was the idea of winning the competition. Winning and competition became an integrated motivating factor that propelled the participants to learn engineering design. Finally, all eight of the participants shared that avoiding punishment or failure avoidance (Atkinson, 1964) was a motivating factor. For example, as the Robosub team realized that they would not be performing well in the Robosub competition, they changed their strategy from trying to win to trying to avoid failing. While this new strategy changed the type of learning
outcomes the students focused on and the depth of learning that took place, it still
provided a motivation to learn.

In What Context Does Motivation Occur, Individually and in Interaction with
Others?

For all eight of the participants, working on hands on projects was the most
important context to bring about motivation to learn. Hands on projects provided the
participants with an opportunity to have a more concrete and less abstract learning
experience, which is based in another context that the participants often mentioned as
“real world scenarios.” These include real problems that the students may face in their
future roles as engineers. In nearly every participant’s responses, a negative experience
with lecture-based courses was discussed. The participants shared that they
found lectures boring, tedious, and either challenging to understand or so simple that it inspired
them to skip class sessions. However, when the participants relayed stories of utilizing
hands on projects in courses, real world scenarios, or both, as part of the engineering
design contests, they experienced what Thomas (2000) suggested: their attitudes toward
learning improved, along with their motivation to learn.

The participants spoke about lectures and being read to out of the text as a waste
of their time, often stating that they don’t need to go to class to be read to, but instead
class should be about understanding connections and how the concept being taught will
be valuable as a component of their future engineering role. This need to connect the
dots of lessons to authentic real world problems seems to be fulfilled by hands on
learning projects like engineering design competitions because, as Lombardi (2007)
points out, learners look for connections.
Another context that all eight participants felt brought about motivation to learn was through failure. While not all participants spoke about failure in the same way, each was motivated to learn by failure. Chad, Connor, Darian, and Zane each saw failure as something to avoid. As Atkinson (1957, 1964, 1966) theorized, individuals appear to be motivated in one of two ways, either to achieve a goal or to avoid failing. For the participants who were motivated by failure, they were moved to action by a desire not to look bad, not to tarnish their team’s good reputation, and to avoid embarrassing themselves and their coaches—what Nicholls (1984) called ego involvement in motivation. Slightly different was the motivation which was described by Adam, Lewis, Wendell, and Tristan. These participants believed that failure propelled them to future behavior. In their minds, failure gave them motivation to keep going, to keep trying, and to figure out the correct answer. For instance, Lewis saw failure as a launching point for future goal making. Lewis used the idea of failing as a charge or a call to action to be motivated to not let it happen again. Lewis also saw failure as feedback that said, “Keep going and keep trying until you figure it out”. In addition, Tristan shared that failure is a part of science and that failure can be an unwelcome yet valuable teacher.

Beyond the desire to avoid failure is Atkinson’s (1957, 1964, 1966) other side of achievement theory, which is motivation derived from setting and desiring to achieve a goal. Six of the eight participants described being motivated by the desire to achieve the goal of winning the competition. According to five of the participants, Adam, Chad, Connor, Lewis, and Wendell, they believed that one of the necessary components for an engineering design competition to motivate someone is that there must be some sense of competition. While Johnson and Johnson (1996) warn that learners competing do not
learn as deeply as learners that are cooperating, the students described competition as a superior way to create extrinsic motivation. Each of the participants was asked whether they thought the Robosub and Roboboat competition would be as motivational if it were not a competition. Those with a strong sense of intrinsic motivation for the topic said that they thought it would be less motivational, but they would still see the benefit in the event. Those who described less intrinsic motivation in their interviews felt that it would be much less motivational and less appealing to them. Moreover, Adam, who did not describe any intrinsic motivation in his interviews, believed that Robosub, without competition, would not motivate him to learn.

Several participants described hoping to land a job or start their career as a context of motivation. These participants believe that the engineering design competitions can help them obtain a career. In this context, the career serves as an extrinsic goal and motivator that the students believe they can achieve. The desire to be hired because of the competition becomes a goal and serves as the achievement, as described in Atkinson’s (1957, 1964, 1966) achievement theory.

Another context that the participants disclosed was the concept of a deadline providing a sense of motivation. While researchers such Amabile, Dlejong, and Lepper (1976) and Deci, Vallerand, Pelletier, and Ryan (1991) have stated that deadlines will seriously hamper an individual’s intrinsic motivation, four of the participants described deadlines as providing a sense of finality and a sense of structure that they desired. Ariely and Wertenbroch (2002) found that self-imposed and externally imposed deadlines assisted in getting tasks accomplished. The participants in this study seem to have said that deadlines provide a sense of focus and help to prevent procrastination. Several
participants went as far as to say that additional deadlines should be instituted throughout the year so that individuals would be motivated to do work earlier and not wait until the end of the year when the deadlines were looming.

A final context described by the participants was the concept of being challenged. As Deci and Ryan (1991) explained, humans gravitate toward mastering a subject; they have a need to be engaged and to integrate new experiences into their lives. Deci and Ryan also shared that individuals have an intrinsic need to feel and be challenged. This seemed to echo how Adam, Connor, and Tristan responded; they believed that being challenged provides them with the motivation to learn. These three participants shared that, as students, they wanted to feel as though they were learning and being challenged. They described the absence of being challenged as both boring and monotonous. They believed that challenges made them feel as if they were discovering something that others had not previously discovered. Connor went as far as to say that he felt most challenged and most motivated when the subject is something that not even the professors know how to master—when everyone is discovering together.

Who Helped Bring about Motivation for These Student Contestants?

The participants of this study felt that there were numerous individuals that helped to bring about motivation both during the preparation for the competition and during the competition itself. Chief among those who helped bring about motivation were the participant’s teammates. A plethora of reasons were given as to why their teammates were so influential on their motivation. Those reasons included the following: a) a desire to impress their teammates; b) not wanting to disappoint their friends and colleagues; c) there were expectations to which they felt they needed to achieve; d) the teammates
served as a model that others could emulate; and d) they were inspired to act by other teammates’ attitude, work ethic, and/or persistence.

In addition to being motivated by their teammates, Zane and Darian acknowledged that the competitive, yet typically friendly, relationships built between them and members of the opposing team were often motivational. Zane shared that it was common for competing teams to share ideas and even provide explanations on how they were able to accomplish engineering designs. Darian, too, acknowledged that the competitors sometime become friends. He shared that a friendly rivalry would come about and that comparing and judging his own success against the other teams provided a sense of motivation.

In addition to their teammates being a source of motivation, six of the eight participants also saw their coach or mentor as a source of motivation to learn. Each of these six participants shared the importance of impressing and receiving praise from their coaches. The six participants shared two reasons for wanting to impress their mentors. The first reason appeared purely extrinsic in its nature and was tied into the participants’ belief that doing well on engineering competitions might lead to a job in the future and/or current and future networking opportunities. These participants believed that if they impressed their coaches that their coach might introduce them to the competition judges and other industry executives that attend the competition. The second reason that participants provided for being motivated by their coaches was a sense of inspiration. These individuals saw the faculty advisors as sacrificing their time and talent to help the team, and they felt it was their duty to learn and, in turn, perform well in order to honor the faculty advisor’s gift of their time.
Finally, Darian and Wendell shared that they felt a profound sense of motivation from outside of the competition itself. They believed that members of their family provide a sense of motivation to learn. For example, Wendell shared that he felt a sense of responsibility to provide for his mother. He saw the competition as a way of preparing him for his future career; a future career was a way to give back to a mother who had sacrificed so much for him. He shared that when he was struggling with a class or struggling to learn a difficult subject, he remembered his mother’s sacrifice and what he was studying to achieve. Darian, also, was motivated by family relationships. He described the importance of being available for his sister and her son. Darian shared that when he needed motivation to continue studying he would think about the importance of being a role model for his nephew. He said that because his family was a backbone for him, it was essential that he was there for his family.

**In What Ways Does This Motivation Propel Them to Act, Learn, or Achieve?**

The participants described three distinct types of activities derived from their motivation to learn and their experience with engineering design competitions. Chad, Connor, Darian, Wendell, and Zane’s intrinsic motivation in the subject matter and their desire to understand the subject better propelled them to utilize what Knowles (1975) called self-directed learning. The participants and Knowles both described a scenario where the learner decides what needs to be learned, what path will lead to this learning, and assess whether the learning has occurred.

The second set of actions that was derived from the participants’ motivation was varied in nature but could be described as acts that lead the team to be competitive in the competition. The participants described a variety of activities that came from their
motivation including a) meeting competition deadlines, b) working on the components of
the competition with tenacity, and c) being willing to do extra research in order to win the
competition.

The final act, which came from those participants with an extrinsic form of
motivation, was to obtain skills that will prepare them to be a possible, future candidate
for work. These participants felt that by being good at the competitions they could get a
job (or a better job) after graduation and that in order to be good, they had to learn the
engineering design skills that would make them good at the competition and marketable
to potential future employers.

Recommendations

In the next few sections of this chapter, I set out to provide
recommendations for my four primary audiences: (a) the faculty who teach engineering
design; (b) individuals who serve as engineering design coaches; (c) academic
administrators who influence or make policy; and (d) student affairs and other staff
members who work with the students and guide them in their co-curricular education.
Within the recommendations, I have included direct responses from participants as well
as some of my own thoughts. This, once again, provides an opportunity for the
participants to share their voice and to give advice on ways that each of these primary
audiences can assist them in their education. These recommendations are just some of
the many ideas, suggestions, and concepts that have come from this study. A full reading
of the literature review and chapters four and five of this dissertation will allow those
interested an opportunity to consider how they might transfer some of the included
experiences into other contexts outside the situations described in this study.
Recommendations for Engineering Professors

Authentic Hands On Projects

The participants in this study were clear about two suggestions. First, in order for them to be motivated to learn and capable of retaining what they learn, they must be taught in a style that provides them the opportunity to conduct a hands on activity that they see as relevant and authentic to the work they are going to do in the future.

Adam, for instance, suggested that all students should be given the opportunity to learn through hands on projects and felt that faculty should consider having hands on projects as one of the ways that they deliver the lessons in their classes, stating:

Make students participate in competitions or at least work on a project because without physically building something important to your major . . ., you’re just kind of gathering information. And then when you gather things that you can’t see [their purpose], however useful, you let them go.

Likewise, Chad suggested that if faculty members only focus on providing information or knowledge for information or knowledge sake alone, students are not able to understand the applicable use of that knowledge. He suggests that faculty use hands on learning so that students can understand the context and application of the lessons in the real world environment. Chad shared that he believes that when faculty really make applicable connections to the real world, students will have a motivation to do well in the class and other classes that can add to their understanding of the topic. In his words:

Instead of working for the knowledge, because . . . if you don’t have something to apply it to, then you having that knowledge is really not helping anybody. Having these competitions and being similar with what you do in the industry really motivates you to take classes. Like, you know, pushing me to take a class I didn’t even think I’d do, but also, it pushes me to all the classes I’m taking now.
Additionally, Darian suggested that making this connection for students does not necessarily have to be done with hands on projects but that it can also be done in a traditional classroom environment when he stated the following:

When you're teaching the GPS portion of your class, bring in the [Robo]boat, you know, talk about bringing the team members in. So, it's almost like a very … hands on approach learning. Where you bring in the team, they talk about the difficulties that they had with GPS, and then you would go onto your lecture about why, what causes these difficulties? What's the source of these errors? Why is there an error? You know, what you can do avoid. So, you can still continue to learn by showing examples. Real-life examples of as soon as I have had failures with these rather than talking about a theoretical example that might be in a book.

Zane summarized this recommendation in the following way:

Drop the PowerPoints, I mean not all PowerPoints. When I say PowerPoints, my thought isn’t the professor that has a PowerPoint and talks about it a little bit, then goes on the board, works through problems, explaining things. And when I said that, I’m talking about the professor that has a PowerPoint and … he goes through one slide, and then he goes to the next and so on for the whole four, five slides, then an hour 15 minutes class. And, you know, we just sit there and … try to stay awake.

For faculty members interested in providing an authentic environment to their courses and projects, they may want to consider and utilize the work of Reeves et al. (2002). Reeves et al.’s research, which is covered extensively in chapter two of this dissertation, provides faculty members with ten requirements that a project includes to be authentic in nature. These 10 characteristics include: (a) real-world relevance; (b) ill-defined activities; (c) complex tasks over a sustained period of time; (d) different perspective, using a variety of resources; (e) collaborative involvement; (f) opportunity to reflect; (g) interdisciplinary; (h) seamless integrated assessment; (i) completed products; and (j) competing solutions and diverse outcomes. Faculty who endeavor to utilize
Reeves et al.’s approach to authentic based projects will find that they are providing students with more motivation to learn and a more real-world context for their students.

In addition to hands on authentic projects, faculty may also be interested in research related to simulations, games, videos, and social networking in the classroom. Much like Reeves et al.’s (2002) work in authentic based projects, Prensky (2006) and Klopfer, Osterweil, Groff, and Haas (2009) provide insights into how faculty can utilize simulations, games, and other technologies to recreate real world scenarios. Prensky also goes into an in-depth conversation on how simulations, games, and other digital technology significantly enhance students’ motivation to learn.

**Engaged Professors**

A second suggestion that comes directly from a majority of the participants is the concept of an engaged and connected faulty member. The participants shared that one of the quickest ways for them to lose interest in a subject or be demotivated is to have a faculty member that shows disinterest. Zane, like many others, explained that students are looking for someone who is interested in being understood and enjoys explaining how applications work.

Wendell, too, recommended actively involved faculty who show they care. He especially saw this as an important component when students are working on hands on projects, stating:

Try to have more projects available for students to do and . . . not only that, but also try to get . . . more . . . involved in the project . . . or have people who have experience involved. Come in, sit with us, look at what we're doing—actually try and solve problems with us.
Tristan did not sugar coat his thoughts on the subject. He stated that it is easy for students to tell when their faculty members are not excited or do not want to be there. His suggestion was to make sure that the professors are excited to be there and excited to be teaching what they are teaching. He stated, “If your professor wants to be there less than you do, then that's very demotivational.”

From my own experience, I see many faculty members who are highly dedicated to their students. They are constantly working to perfect their teaching skills and will utilize their research to augment lessons in the classroom. These faculty members are models of what students would define as engaged and interested professors. They sacrifice their time and give of their talent. Still, we all have bad days, and there are those that could use development in this area. In fact, the need to improve in teaching skills is a fairly common concern among universities. Richlin and Essington (2004) speak to this need in the following quote:

Docto...
development of teaching skills. These centers for teacher development are ideal for any faculty member who would like to take up the charge of moving from faculty-centered teaching to learning-centered teaching. They are also for those who want to learn skills in the area of authentic learning, experiential learning, inquiry-based learning, collaborative learning, or any number of other concepts that will help faculty to be more engaged with their students. Attending workshops, participating in learning communities, and researching areas of scholarship all provide faculty members with ways in which they can strive to be better engaged professors.

For those faculty members who would like to take advantage of the benefits of engineering design competitions and other authentic-based experiences, I specifically recommend development in the areas of simulation and authentic-based learning experiences. Another key developmental area for faculty members would be in understanding how cohorts develop and group cohesion comes about.

**Encourage Reflection**

In order for an engineering design competitor to fully realize the benefits of learning from the engineering design competition, they must reflect on the learning. A large portion of the literature review is written on the importance and necessity of reflection. In order for a student to fully comprehend what has been learned and how that learning can relate to past learning and future problems that will need to be resolved, the student should critically reflect on their experience in a variety of ways. Every individual credited as the great minds of experiential learning (Dewey, 1938; Lewin, 1951; Piaget, 1952 & 1964; Kolb, 1984) advocate for the importance of reflecting. In its simplest terms, experiential learning can be compared to children’s blocks. There are those
experiences or blocks that serve as a foundation, and then each subsequent experience or block is stacked upon the last to make a complete structure. However, without reflection, the student is unable to utilize the block within the structure because the block or the lesson is not fully formed.

Beyond the points advocated by the authors of experiential learning, there are a variety of other times within this dissertation were reflective practices are highly encouraged or required. For instance, there is the call for reflection implicit in Knowles (1980) concept of self-directed learning. In order for Knowles’ concept of self-directed learning to have any effect, students must learn to be reflective about their past learning. Without reflecting on past experiences and past learning, students are unable to decide what needs to be learned in the future; they cannot determine what path will lead to their learning and have no basis for how to assess whether the learning has occurred.

Ryan and Deci (2000) are also advocates for the importance of reflection in learning and specifically in learning motivation. They share their thoughts on how reflection affects extrinsic motivation at the integrated regulation domain in the following:

Integration occurs when identified regulations have been fully assimilated to the self. This occurs through self-examination and bringing new regulations into congruence with one’s other values and needs. The more one internalizes the reasons for an action and assimilates them to the self, the more one’s extrinsically motivated actions become self-determined. (p. 62)

Ryan and Deci (2000) are suggesting that in order for students to be fully moved by a motivator they must assimilate that motivator into themselves. They must reflect on how the motivator relates to themselves, their values, and their beliefs. For instance, students may be extrinsically motivated by hands on learning and authentic-based
learning at the integrated level if these external forces are, in fact, an integral part of who they are: meeting their needs and values and part of their self-identity. The only way a student can determine if these motivators have, in fact, become part of their identity is to reflect on the role they play in their lives and in their learning.

In order for students to take full advantage of reflection, they must reflect on more than what they learned. Instead, they should instead reflect on the experience in four different ways. Grossman (2009) provides structure and suggestions for these four different types of reflection that are necessary for students to use in order to fully comprehend and later utilize what they have learned. These types of reflections include: (a) content-based reflection, (b) metacognitive reflection, (c) self-author reflection, and (d) transformative reflection.

Grossman’s (2009) first reflective type is labeled “content-based reflection”, which calls for students to consider the experience that they have had and map that experience to specific learning outcomes. For instance, in the engineering design competition, the participants would reflect on how they learned to use GPS waypoints during the competition and how this skill might be essential for them in the future.

Secondly, Grossman (2009) provides information on how to encourage students to do “metacognitive reflection” or the concept of reflecting on how they think during an experience. For instance, a student who reflects on how they think can then utilize what worked by employing the same thought processes in similar situations in the future. In the case of engineering design competitions, the students need to reflect on their thought process and learn from it so that they can either repeat the process or avoid the same pitfalls in the future when facing other design competitions or actual real life situations.
Engineering design competitors would use metacognitive reflection to answer how they got a boat that has been pulling to the left to suddenly go straight. It is not enough for the student to say ‘I played with the code until it worked right’. They should know why changing the code worked and what they would do in the future in the event that they need to rewrite the code again. This concept of metacognitive reflection is essential to being able to experience self-directed learning and to learning in the authentic-based learning style.

Grossman’s (2009) third suggested type of reflection is the “self-author reflection”. Grossman describes self-authorship similarly to self-talk and the scripts that people use to build themselves up or tear themselves down. Similar in nature to Weiner’s (1985) attribution theory of motivation, Grossman suggests the importance of students reflecting on the experience in a way that they can write positive self-scripts. Weiner might suggest that students reflect on the situation and purposefully utilize the concept of internal attributes. For instance, both Grossman and Weiner would ask engineering design competitors of the roboboat who have done poorly on a time trial to reflect on the event. The competitors at that moment could blame the judges, the wind, or a duck floating by causing wake or anything else to blame but themselves. However, the concepts of self-author and attributes would call on the competitors to consider a different mindset, such as, “We did not do well on the time trial, but since we never tested the motor, we are in fact lucky the boat was propelled forward in the first place.” Using Grossman and Weiner’s concepts allows the students to reflect on what really took place and requires them to consider what really can and should be learned from a situation. Secondly, this type of reflection provides the students the opportunity to look
inward and complete a critical self-assessment in to their behavior, their thoughts, learning, attitudes and much more.

Grossman’s (2009) final suggested type of reflection is “transformative reflection”. Students called to practice transformative reflection are asked to reflect on previously held assumptions and how, through their experience, those assumptions have changed. For instance, engineering design competitors might assume that utilizing GPS waypoints is the best way to navigate through a buoy channel, but once the competitors have had an experience they may find that visual sensors, laser sensors, or 3D mapping might all be more effective and accurate. This realization becomes transformative when the student no longer chooses the waypoint method by habit, but instead reflects upon the possible choices of guidance systems and chooses the most appropriate system based upon reflection and past experience.

Those faculty members interested in learning more about how to encourage their students to critically reflect on their learning should more fully consider the research of Grossman (2009) and his four types of reflections. In addition, there are numerous studies on the effectiveness of reflective journals, e-portfolios, reflective exams, and group discussions that might be of interest.

**Recommendations for Coaches/Mentors**

**Become an Expert Coach/Mentor**

In terms of outside individuals who helped to bring about motivation to learn, the participants were quite clear that they need the assistance and guidance of an expert coach or mentor. Hackman et al. (2000) address the need for an available expert coach. Additionally, while Campion et al.’s (1993, 1996) studies are focused on the work
environment, there are clear connections and similarities that can be seen between a work supervisor and the role of faculty mentor in an engineering design competition. How to be an expert coach or mentor is described in the following way:

The role of help provider is not, of course, to dictate to group members the one best way to proceed with their collaborative work. It is, instead, to help members learn how to minimize the ‘process losses’ that invariably occur in groups (Steiner, 1972) and to consider how they might work together to generate synergistic process gains. (Hackman et al., 2000, p. 116)

Hackman et al. (2000) are essentially saying that an advisor, coach, or mentor provides guidance and support and assists with retention but would never go as far as to take over the work or micromanage a process.

Connor shared a first-hand experience with what happened when one of his past coaches did not heed the advice of Hackman et al. Connor described the situation in the following way:

We were talking about what we’re gonna do [at the competition] . . . We were like, “Well, we wanna do this, this, and this .” and the advisor was like, “Yeah. I don’t think you guys should focus on that.” He was like, you know, “Don’t do that. Do this instead.” So it’s actually kind of like . . . the advisor was dictating what we should be doing, and that was just . . . that was very demotivational.

For those individuals who would like to avoid an authoritarian approach and continue to grow as “expert coaches” Hackman et al. (2000) share the following three recommendations:

1. For effort. Helping member’s coordination and motivation problems (process losses that can waste effort), and helping them build commitment to the group and its task (a process gain that can increase effort).
2. For knowledge and skill. Helping members avoid inappropriate weighting of different individual’s ideas and contributions (a process loss), and helping them learn how to share their expertise to build the group’s repertoire of skills (a process gain).
3. *For performance strategies*. Helping members avoid failures in implementing their performance plans (a process loss). And helping them develop creative new ways of proceeding with the work (a process gain). (pp. 116-117)

Utilizing these three recommendations puts the coach or mentor into the role of help provider and educator and may prevent the coach/mentor from accidently demotivating the team.

**Careful Selection of Team Members**

In addition to being heavily influenced by the coach or mentor, the participants also shared that they were highly influenced by their own team members. This influence extended to both affecting their desire to participate in the competition and also to being motivated to learn by the competition. Because other team members are so influential, it is essential that coaches and others involved consider the makeup of the team. A variety of concepts should be weighed before forming an engineering design competition team. Coaches should ask themselves some of the following questions: “Am I creating a team that can be coherent? Do I have the right mix of experienced team members and new team members? Have I considered the amount of time this team will need in order to make it through the forming and storming phase in order for the team to get to the norming and performing stage?” Anyone considering teaching engineering design through an engineering design competition must be aware that the makeup of the team that they will put together will have a profound effect on both the success of the team and also the learning that occurs for each individual member.

As Zane, Tristan, and others pointed out, team members can impact motivation to learn in both a positive and a negative way. Thibaut and Kelley (1959) agree with the
participants’ responses and point out that not appropriately vetting members of a team can result in a team that is hindered from successfully achieving their goals.

A coach who is interested in effectively guiding the group through team conflict should consider the literature by Tuckman (1965) which provides for a better understanding of the life cycle of a small team. In addition, the coach should be aware and vigilant of the six hindering factors which were identified by Johnson and Johnson (1996). These factors include: (a) social loafing; (b) free riding; (c) dominant response; (d) group immaturity; (e) lack of normative integration; and (f) the formation of groupthink.

While being vigilant and working to overcome any of the six hindering factors is a necessary step to a successful engineering group, the most important role a coach or mentor can play is that of cohesion builder. Roark and Sharah (1989) provide a number of recommended factors that are essential to group cohesion; these include empathy, self-disclosure, acceptance, and trust amongst the group members.

**Coping through Humor**

Another important way that the coach/mentor can support the engineering design competitor is to assist in the creation of a less stressful environment. Reading through the reflections of the participants, it is clear that the engineering design competition creates an environment of competition with deadlines and expectations which weigh heavily on the competitors. The participants of this study mentioned their desires and hopes for a job and recognition, of their disappointment in their performance at Robosub, and of difficulties working alongside some of their teammates, and disagreements with advisers.
Deci and Ryan (2012) point out that if external motivators cause a loss of control or autonomy or if the extrinsic motivation causes the competitor to act in an inauthentic way, then the external motivator will cause a loss of internal motivation. Said another way, if external motivators (i.e. deadlines, competition, or interactions) create conditions where people feel they no longer have control over a situation or to feel as if they are being asked to do something with which they are uncomfortable, then their motivation is diminished. Hackman et al. (2000) would suggest that a strong performing coach/mentor would try to assist the competitors in coping with this stressful situation, preventing process losses that can waste effort and instead refocus on building up the community in order to promote increased effort.

Martin, Kuiper, Olinger, and Dance (1993) submit that one of the most effective ways that stressful situations can be defused is through humor. Martin et al. suggests that humor, as a coping mechanism, allows individuals to refocus their feelings about the event. Humor allows the individual to interpret the stressful situation as a challenge rather than as a threat. It is, therefore, vitally important that humor, whimsy, and lightheartedness be introduced to the engineering competition environment, decreasing the chance of a situation threatening a competitor’s autonomy. In Martin et al.’s (1993) study, a number of positive reasons to cope with humor were found. These reasons include the following:

Individuals reporting higher levels of coping humor also perceived themselves as having more control over their own lives and felt less overwhelmed, less anxious, and less stressed than those individuals scoring low on the coping humor scale. The coping humor scale was also significantly correlated with two of the ways of coping subscales. Individuals with higher levels of humor reported greater use of the coping strategies of confronting ($r=.32, p<.025$) and emotional distancing ($r=.27, p<.05$). Thus, high humor individuals dealt with this stressful situation in a
more direct problem-focused fashion while at the same time distancing themselves more emotionally. (p. 95)

Having the ability to deal with stressful situations in a more direct, problem-focused fashion and not viewing the stressful situations through a deeply emotional lens seems ideal.

Flowers (2001) also discussed the benefits of humor. Flowers specifically advocates for its use in technology education, stating that it can provide stress reduction, make the instructor more approachable, and help to make the professor more motivating. Flowers goes on to say that humor is especially helpful when students are expected to engage in creative problem solving. Flowers has shown that humor allows students to feel as if they can be more open to learning and taking chances, and it allows them to increase creativity instead of being repressed by the fear of failure. Flowers does point out, however, that professors must be conscious of cultural contexts and must ensure that their humor does not become cruel or detrimental to the learning environment. In order to provide procedures for how educators can utilize humor, Flowers quotes Rareshide’s (1993) seven guidelines for the use of humor in the classroom. These guidelines are useful whenever working with students in or out of the classroom:

- First, teachers should be aware of and receptive to humor’s many uses, particularly those cited above.
- Second, humor should never be used to ridicule or embarrass a student.
- Third, humor should never be aimless; it should serve a specific purpose even if it is used spontaneously.
- Fourth, humor should be made appropriate to the students’ ability levels.
- Fifth, teachers should reorganize the use of spontaneous as well as planned humor; they should incorporate both into their teaching.
- Sixth, teachers should laugh at themselves occasionally to show their students that they are ‘real people.’
- Seventh, they should use sarcasm only if it is of the playful kind. (as cited in Flowers, 2001, p. 11)
Those coaches/mentors who are interested in providing coping humor, whimsy, or lightheartedness to a possible stressful situation or as a tool to assist in teaching, do not have to become standup comedians. Instead, Martin (1996) suggests that if a person smiles, laughs, and otherwise displays mirth in a wide variety of life situations they can be said to have a coping sense of humor.

Recommendations for Academic Administrators

Provide Appropriate Resources

Engineering design competitions cost money, not thousands of dollars, but they are not free. Providing engineering design competitors and their coaches and mentors with the appropriate financial resources is essential in ensuring that the team has the equipment necessary to create an authentic experience. While the budgets from school to school vary, a discussion with the team captains and their faculty mentor should occur to consider the appropriate amount of funding to provide. When considering an appropriate budget, it is important to align the administrators’ expectations with the budget that is afforded the group. In addition, it is important that the group not be given unlimited funds. Unlimited funds can be just as restricting on an engineering design team as having no funds. Unlimited funds can restrict the creativity of the team who might not come up with a solution to a design problem because they rely on purchasing their way out of an issue rather than designing a solution. In addition, unrestricted funds take away from the authentic nature of the experience. Having a realistic budget makes the experience similar to the situation that these students will face when they are using these skills in the work force. Chad spoke to budgets as a source of pride, stating: “We do with a lot less
funding than other teams. We’d do better if we had a little bit more money and, if we had a ton of money, I think we’d do worse.”

Funding for equipment is not the only support and resources required. In addition, there are other needs such as travel expenses, shipping, storage, and lab space. Tristan shared the following list of recommendations of support:

We have a lab space which is fantastic. I mean, I'm not sure how we'd do all this if we didn't have that—travel which can be very expensive, finding people to do something that we need, and give us space or give us testing areas.

Supporting engineering design competitions provides a group of engineering students with hands on authentic experiences that can produce deeper learning and students who feel they have been supported. There are multiple reasons for wanting to have students who experience this type of support. The benefits could range from students who can demonstrate that they have achieved important student learning outcomes to students who remain at the school because they feel supported to students who become alumni with a feeling of affinity to a school who supported them and made it possible for them to gain marketable skills.

**Promote a Learning Culture**

One of the earlier recommendations of this study was for faculty to become more learning-centered, and for them to move away from an overreliance on PowerPoint and other faculty-centered techniques. In order for faculty to be comfortable with this move or to feel as if a change in their teaching techniques is appropriate, academic leadership must encourage such a move. Examples of encouragement could be ensuring that dollars are available for faculty development and providing research grants for those faculty members interested in pedagogy and other forms of teaching and learning (SOTL).
research. Other examples of encouragement could be stressing the importance of attending workshops led by the development center for teaching or providing budget dollars for faculty members to attend appropriate conferences and other developmental programs. Additional ways to encourage faculty include recognizing them with teacher awards, stipends, course releases and, more importantly, recognizing faculty members who move to a learning-centered approach through the tenure and promotion process.

In addition to encouraging a learning-centered environment, academic administrators must also set engagement as an expectation. As was stated in the recommendations for faculty members, the participants felt that engaged and excited faculty members were essential for their success. Utilizing many of the same techniques just discussed, academic administrators can encourage faculty to be more engaged with their students.

**Recommendations for Student Affairs**

**Promote the Experience; Promote the Student as a Whole**

Serving as a student affairs staff member for 10 years out of my 12 years in higher education has provided me with the perspective that all student affairs professionals are integral guides in the lives of the students with whom we come into contact. Anyone who has been formally trained in the profession of student affairs likely has been influenced by the 1937 *Student Personnel Point of View* document. Among other things, this document serves to remind us that finding a job and achieving skills for that job is not the only purpose of coming to an institution of higher education. Whether the student is conscious of it or not, attendance at a university serves to educate the student as a
whole. According to the *Student Personnel Point of View* document, a *whole* student’s education should include the following:

His intellectual capacity and achievement, his emotional make up, his physical condition, his social relationships, his vocational aptitudes and skills, his moral and religious values, his economic resources, and his aesthetic appreciations . . . development of the student as a person rather than upon his intellectual training alone. (American Council on Education, 1937, p. 1)

Reviewing the American Council on Education’s definition of a whole student gives the reader a clear idea of why a student affairs professional would want to strive to empower and educate the whole student. It is also clear from the definition how important a role the student affairs professional plays in assisting students in their endeavor of becoming a whole person.

Throughout my time working in student activities, I have had numerous times where students of various engineering design competitions have come to me for help. This help has ranged from issues of how to communicate with other team members and how to ask a mentor to allow for autonomy to how to balance the team’s budget. Within any activity that is built around an authentic experience, there is a role for student affairs staff to play a part. Like the engineering faculty member that serves as a coach and mentor, a student affairs staff member can serve in the capacity of help provider, working with the students on developing leadership skills, assisting the student through small group development issues, guiding the students through budget conversations, and helping the student make connections with what they are learning in the classroom and competition and applying it to other aspects of their lives.

In addition, student affairs staff can provide some very practical assistance. This can include helping the student group to find on-campus space, promoting the experience
to new students through orientation, and representing the students in budget and other
policy conversations. Student Affairs professionals, who have the capacity, should work
with their college or schools of engineering to see how they can assist in this important
learning and personal growth experience.

Recommendations for Future Research

When choosing a topic for my dissertation, it was Phillip Wankat’s 2005 research
brief titled Undergraduate Student Competitions that was my initial inspiration. Within
Wankat’s research brief, he shares a number of benefits for undergraduates who partake
in student competitions. In his conclusion, he suggests that further research
should consider the hypothesis: “Well-designed student competitions increase student
learning, help them learn practical aspects of engineering, and motivate students to work
harder” (Wankat, 2005, p. 347). I did not choose to test Wankat’s suggested hypothesis
because I maintained then, and still maintain now, that while it would be a worthwhile
research study, it is premature and should be preceded by a number of other studies. This
dissertation sought to answer one of the most important elements of Wankat’s question:
“What does motivation look like for engineering design competitors?” Through the lived
experiences and perceptions of eight engineering design competitors, we know a bit more
about how they describe motivation as it relates to their participation in their engineering
design competition.

Future researchers who are interested in testing Wankat’s hypothesis first may
want to consider the following research questions: (a) What makes up a well-designed
student competition? (b) What student learning outcomes can be taught from engineering
design competitions? and (c) How effective is the assessment of engineering design
competitions? Once these questions are answered, then future researchers may want to test Wankat’s valuable question.

Another topic, which I personally am interested in considering, involves women as engineering design competitors. Yonder (2011) points out that women received 18.4% of engineering bachelor’s degrees and 22.6% of engineering master’s degrees for the 2011 academic year. He also shared that this number has not changed significantly from preceding years. At the roboboat and robosub’s institution the percentage of engineering student that are women is 16.65% but not a single female was a member of either team studied. For other competitive engineering design competition teams at the same university, the percentage is slightly higher. When observing the International Roboboat Competition, there were very few females present. These facts lead me to suggest several possible future areas for investigation: (a) Are women, in fact, underrepresented in engineering design competitions? (b) If they are underrepresented, why? (c) What would motivate women to participate in engineering design competitions? and (d) How would a female engineering design competitor describe her life experience with the phenomenon of motivation to learn and would it differ from male students and in what ways?

A third, and my final, research recommendation is to consider how engineering design competitions can help to achieve an optimal experience or flow. Csikszentmihalyi (1997) describes optimal experience or flow as pure and effortless enjoyment. Within my own study, Connor, for instance, described achieving optimal experience or flow in his interview when he shared that while he works on robotics nothing disturbs him or distracts his focus and that he seems to have blinders on in an attempt to get the task accomplished. However, more research should be done in what would perpetuate this
optimal experience or flow so that educators can look for ways to provide students with opportunities for the experience in other authentic learning situations.

In order to determine if and how flow occurs in engineering design competitions, future research could be done by utilizing the Experience Sampling Method (ESM), according to Larson & Csikszentmihalyi, 1983. Csikszentmihalyi has utilized ESM throughout his research, and Deci and Ryan (1985) drew from ESM during the creation of the self-determination theory. Utilizing ESM in this type of research would require that the participant work on their engineering design competition goals as they normally would. Periodically, a timer would go off and the participant would be asked to reflect on their motivation and their enjoyment at the time that it was occurring and to record their reflection in a journal. Specifically, the participants could be asked to explore their feelings and perceptions of how the extrinsic motivators that were identified in this study are affecting their behavior at the time their reflection timer rings. This would help to determine whether motivators identified in this study, such as deadlines, competitors, teammates, hands on projects and other extrinsic motivators, are actually moving the participant to action, which would be essential to classify them as motivators. In addition, those motivators that were found to help create optimal experiences or flow would assist educators in recreating optimal learning opportunities.

Many other research methodologies could be utilized to answer the question what brings about an optimal experience for engineering design competitors? Both qualitative and quantitative surveys, multi-case studies, and focus group research are just some of the other methodologies that could be utilized to explore the concept of flow or optimal experiences in engineering design competitors.
While there are many variables that could be considered in future studies about engineering design competitors, the significance of optimal experience or flow is tied to Ryan and Deci’s (2000) belief that enjoyment is a chief characteristic of both the integrated regulated level of extrinsic motivation and intrinsic motivation. Therefore, understanding what motivators and/or moments of a participant’s experience brings about enjoyment, whimsy, and/or fun seems essential in helping educators to better motivate students to learn.

**Final Reflections**

Sir Isaac Newton has been credited with saying, “If I have seen further, it is by standing on the shoulders of giants.” Nothing could be truer for this dissertation. Each step of the way, I have relied on giants, the social researchers that have come before me, classmates who have shared their experiences, advice from my committee members, friends, coworkers, and family who have supported me, the engineering faculty who served as mentors for this study’s participants, and the authors who are quoted within this dissertation.

To see farther into the life experience of engineering design competitors, I have stood on the shoulders of Creswell (2007, 2012), whose quotes and sage advice provided a clearer understanding as to methodology, Moustakas (2004) and Sokolowski (2000), a pair of giants who have guided my understanding of the meaning of phenomenology (Sokolowski), and the use of phenomenology as a research method (Moustakas). A summary of giants would also need to include van Kaam, whose work into phenomenological analysis was an essential part of my research, Deci and Ryan, who
even today continue to define motivation studies, and the fathers of experiential learning, Dewey, Lewin, and Kolb.

I would be remiss if I did not mention two others. First, my chair, Dr. Nancy Bentley: without my chair, I shudder to think whether or not I would have ever completed such a monumental task. Her mentorship, friendship, and guidance have been the model of how to guide a dissertation. She could write volumes on how to provide both challenge and support to a student.

Finally, this dissertation would not exist if it were not for the eight participants who freely shared their stories of learning, engineering design competitions, tireless work in robotics, and their deeply personal stories about their hopes, aspirations and dreams that can only be accomplished through a strong engineering education. It is my hope that this research will help educators to strengthen that very education.

Through the dissertation process, I had the opportunity to reflect on my own role as a student. This reflection allowed me to remember that as a young child I was often humiliated by rote memorization, discouraged by my inability to learn from a lecture, and aggravated by my lack of comprehension when reading from a book. Hands on projects were not the answers to my disabilities. Tutoring, hand-eye coordination exercises, and counseling were required to overcome those challenges. Hands on experiential projects certainly did add to my self-confidence, allowing me to feel as if I, too, could succeed in learning and that I could be as smart as any other student in the room. Knowing this part of my story, it is no wonder that I identify with the participants. It is because of this kindred spirit and deep understanding that I sincerely hope that this research has met the task of giving a voice to the individual students and provided a deep understanding of the
essential structure of their experience, which is a desire for more engaging professors, more challenging educational experiences, more real-life educational scenarios, hands on projects, and freedom from the doldrums of ineffective PowerPoint-centered lectures.

Finally, I encourage all who read this dissertation to allow experience to be their educator, to discover what inspires them, and to never let fear of failure be anything more than a sense of motivation. To encourage this spirit, I share the following poem. Written by Greek poet C.P. Cavafy, it urges us all to encounter, to experience, and to live a long life of learning.

“Ithaka

As you set out for Ithaka
hope the voyage is a long one,
full of adventure, full of discovery.
Laistrygonians and Cyclops,
angry Poseidon—don’t be afraid of them:
you’ll never find things like that on your way
as long as you keep your thoughts raised high,
as long as a rare excitement
stirs your spirit and your body.
Laistrygonians and Cyclops,
wild Poseidon—you won’t encounter them
unless you bring them along inside your soul,
unless your soul sets them up in front of you.

Hope the voyage is a long one.
May there be many a summer morning when,
with what pleasure, what joy,
you come into harbors seen for the first time;
may you stop at Phoenician trading stations
to buy fine things,
mother of pearl and coral, amber and ebony,
sensual perfume of every kind—
as many sensual perfumes as you can;
and may you visit many Egyptian cities
to gather stores of knowledge from their scholars.

Keep Ithaka always in your mind.
Arriving there is what you are destined for.  
But do not hurry the journey at all.  
Better if it lasts for years,  
so you are old by the time you reach the island,  
wealthy with all you have gained on the way,  
not expecting Ithaka to make you rich.

Ithaka gave you the marvelous journey.  
Without her you would not have set out.  
She has nothing left to give you now.

And if you find her poor, Ithaka won’t have fooled you.  
Wise as you will have become, so full of experience,  
you will have understood by then what these Ithakas mean.”
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APPENDIX A

INFORMED CONSENT FORM
Dear prospective participant,

You are invited to participate in a study entitled *A Phenomenological Study: Motivation as Experienced by Engineering Design Competitors at a Selective Engineering University*. The purpose of this research study is to learn about engineering design competitors’ experience with motivation, as it pertains to their role as a student competitor in International Robosub and Roboboat Competitions. The study will also provide educators with a better understanding of how to use engineering competitions in a way that will motivate their students to learn the design process.

The researcher for this study will be Aaron D. Clevenger, a doctoral student in the Higher Education and Organizational Change program at Benedictine University. Specifically, I will aim to answer the following research question: While preparing for and participating in International Robosub and RoboBoat Competitions, what experiences – actual acts, specific behaviors, or other moments – bring about motivational responses for student contestants? To gain that information, the following sub-questions will be explored: (a) How do student contestants describe their motivation and ascribe meaning to it personally?: (b) In what context does motivation occur to them, individually and in interaction with others?: (c) Who helped bring about motivation for these student contestants?: and (d) In what ways does this motivation propel them to act, learn, or achieve?

If you choose to accept this invitation, you will be agreeing to participate in a 60-90 minute interview at a location and time convenient to you. The interview will be audio- and/or video-recorded and transcribed. You will be asked to respond to a series of questions pertaining to the research purposes. Follow-up interviews may be requested depending on the research needs. The interview transcript will be presented to you for verification of accuracy.

You can expect anonymity and confidentiality regarding your participation. Your actual name will be known only to me as the student researcher. To reiterate, your name will not be used in any way to connect you to any of the data. Your interview will be given a secure code, and a pseudonym will be assigned to you. Excerpts from your interview will be included in the final dissertation document or other later publications; however, your pseudonym will appear in these writings.

All paper forms will be converted to an electronic file, which will be maintained on a password-protected computer. The hard copies of the interview transcripts and all electronic and audio files pertaining to your participation in this study will be stored in a locked cabinet for ten years and destroyed afterwards, if no longer needed.

Participation is voluntary, and you may choose not to answer any particular question or withdraw from the interview at any time without consequences. There is essentially no risk associated with choosing to participate in this research project.
This study has been approved by the Institutional Review Boards of both Benedictine University and [University Name] University. The Chair of the Benedictine University IRB is Dr. Alandra Weller-Clarke who can be reached at aclarke@ben.edu or at (630) 829 – 6295. The Chair of the [University Name] IRB is Dr. [Name] who can be reached at [Email] or at (386) 226-7035.

This study is being conducted, in part, to fulfill requirements of my Ed.D. degree in Higher Education and Organizational Change at the graduate school of Benedictine University in Lisle, IL. If you have questions regarding this study, please feel free to contact me at aclevenger@gmail.com, or at [Phone Number]. You may also contact my dissertation director, Dr. Nancy Bentley, at nbentley@ben.edu or at [Email].

You will be provided a copy of your signed consent form. Please acknowledge, with your signatures below, your consent to participate in this study and to have your interview recorded and/or videotaped.

_I consent to participate in this study_
Name: ___________________________ Date: ___________________________
________________________________________
_________________________ ___________________________
[Signature]

_I give my permission to record this interview_
Name: ___________________________ Date: ___________________________
________________________________________
________________________________________
[Signature]
APPENDIX B

DEMOGRAPHIC SURVEY
Engineering Design Competitor Demographic Information Survey

The following form is a demographic information survey for engineering design competitors who will be interviewed for the study, Motivation as Experienced by Engineering Design Competitors at a Selective Engineering University, by Aaron D. Clevenger. Please contact me, if you have any difficulty completing the survey.

Place your unique identifier from the e-mail in the box below *

What is your gender *
Mark only one oval.
☐ Male
☐ Female

What is your age? *
Mark only one oval.
☐ 17-25 years old
☐ 26-30 years old
☐ 31-39 years old
☐ 40 years old and over

What is your major? *

What is your student status *
Mark only one oval.
☐ Full time student (12 or more credits)
☐ Part time student (11 or less credits)

What was your admission status at the time you first enrolled here at the university? *
Mark only one oval.
☐ New student
☐ Transfer student

What is your current year in school? *
Mark only one oval.
☐ First Year (Freshman)
Sophomore
Junior
Senior
Graduate

Please provide your ethnicity *
Mark only one oval.
Latino/a or Hispanic
Non-Latino/a or Hispanic

Please specify your race *
Mark only one oval.
African American or Black
Asian
Caucasian
Multi-racial/ethnic
Native American or Alaskan Native
Native Hawaiian or other Pacific Islander
Choose not to answer
Other: __________

What is your employment status *
Mark only one oval.
Full-time off campus
Full time on campus
Part-time off campus (under 30 hours per week)
Part-time on campus (under 30 hours per week)
Unemployed (looking for employment)
Unemployed (not looking for employment)
Retired
Other: __________

What is your current marital status *
Mark only one oval.
Single
Married
Living with partner  
Separated  
Divorced  
Widowed  
Other:  

**What is your current housing arrangement?**  
Mark only one oval.  
Live on campus  
Rent off campus  
Live with family or friends  
Own off campus  
Other:  

**Choose all that apply to you:**  
Check all that apply.  
- First generation college student (neither parent attended college)  
- Mother completed college  
- Father completed college  
- Guardian or caregiver completed college  
- Spouse completed college  
- Significant other completed college  
- Sibling completed college  

**What is your veteran status?**  
Mark only one oval.  
Non-veteran  
Veteran  

**Are you an international student?**  
Mark only one oval.  
Yes  
No  

**Is this your first engineering design competition?**  
Mark only one oval.  
Yes
In how many design competitions have you been involved?
Mark only one oval.

☐ 1
☐ 2
☐ 3
☐ 4 or more

Please list the name and years of all engineering design competitions you have been involved in.
APPENDIX C

INTERVIEW GUIDE
Interview Guide

1. What does it mean to you “to be motivated to learn”? Please elaborate on your answer.
2. Are there any particular teaching or learning techniques, strategies, or tools that any of your teachers or professors have used that have led you to be motivated to learn? Please describe in your own words what these were and what made them motivational to you.
3. Are there any particular teaching or learning techniques, strategies, or tools that any of your teachers or professors have used that have led you to be demotivated to learn? Please describe in your own words what these were and what made them demotivational to you.
4. Think back to some of your most enjoyable courses. What made them enjoyable?
5. What motivated you to learn in these courses? What demotivated your learning in these courses? How much of the course’s learning outcomes do you remember?
6. Think back to some of your most difficult and challenging courses. What motivated you to learn in these courses? What demotivated your learning in these courses? How much of the course’s learning outcomes do you remember? What made them challenging?
7. Think back to some of your easiest courses. What motivated you to learn from these courses? What demotivated your learning in these courses? How much of the course’s learning outcomes do you remember? What made them easy?
8. Think back to some of your most tedious or boring courses. What motivated you to learn from these courses? What demotivated your learning in these courses? How much of the course learning outcomes do you remember? What made them tedious or boring?
9. Have you ever experienced challenges related to being motivated to learn? If so, please describe those challenges in detail.
10. Describe what you learned from International Robosub or Roboboat Competitions. How were you motivated to learn these lessons?
11. Do you think that there could have been a better way to learn these lessons? If so, how? If not, why not?
12. Please describe what experiences preparing for and/or participating in International Robosub or Roboboat Competitions have been most meaningful to you and why.
13. Please describe as many experiences as you can that reflect how preparing for International Robosub or Roboboat Competitions added to your motivation to learn. Describe, in detail, how you utilized this motivation.
14. Please describe as many experiences as you can that reflect how International Robosub or Roboboat Competitions, itself, added to your motivation to learn. Describe, in detail, how you utilized this motivation.
15. Please describe any experiences you can that reflect how preparing for International Robosub or Roboboat Competitions or participating in the International Robosub or Roboboat Competitions demotivated you to learn. What, if anything, did this demotivation prevent you from doing?
16. Describe, in detail, any interaction with other teammates, advisor/coaches, or any other individuals related to International Robosub or Roboboat Competitions that led to a motivation to learn. Describe, in detail, how you utilized this motivation.

17. Describe, in detail, any interaction with other teammates, advisor/coaches, or any other individuals related to the International Robosub or Roboboat team that led to a demotivation to learn. What, if anything, did this demotivation prevent you from doing?

18. Describe, in detail, any and all roles that you played within the engineering design group. Do you think your role affected your motivation to learn in any way? Did the role of any of your team members affect your motivation? How so?

19. How did your experiences in this competition compare to regular college coursework in terms of motivating you to learn?

20. You were asked to bring an item from the competition or preparing for the competition which represents your motivation to learn. Could you, please, describe your object (or documents) meaning and significance?

21. What other things could your teammates, advisor/coach, or other individuals have done to bring about more motivation to learn?

22. What other things do you wish you could have learned or done that would have added to your success in International Robosub or Roboboat Competition?

23. Suppose that you had a chance to address educational leaders on campus. What kind of advice would you give them on motivating students to learn?

24. In speaking with these same educational leaders, what would you tell them are the most important things that they can do, or stop doing, in order to support engineering design competitions?

25. If you had it to do over again, would you still compete in the competitions? Why or why not?

26. Is there anything that I have not asked you that would be important for me to know regarding engineering design competition’s ability to motivate you or other students to learn?
APPENDIX D

DEMOGRAPHIC DATA
### Demographic Data

<table>
<thead>
<tr>
<th>Name</th>
<th>Race</th>
<th>Ethnicity</th>
<th>Relationship status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>Caucasian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Living with partner</td>
</tr>
<tr>
<td>Chad</td>
<td>Multi-racial/ethnic</td>
<td>Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Connor</td>
<td>Caucasian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Darian</td>
<td>Asian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Lewis</td>
<td>Caucasian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Tristan</td>
<td>Caucasian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Wendell</td>
<td>African American or Black</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
<tr>
<td>Zane</td>
<td>Caucasian</td>
<td>Non-Latino/a or Hispanic</td>
<td>Single</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Family that completed college</th>
<th>Original Admission Status</th>
<th>Year in School</th>
<th>Veteran Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>Father</td>
<td>New student</td>
<td>Sophomore</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Chad</td>
<td>Father</td>
<td>New student</td>
<td>Senior</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Connor</td>
<td>Mother, Father</td>
<td>New student</td>
<td>Graduate</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Darian</td>
<td>Mother</td>
<td>Transfer student</td>
<td>Graduate</td>
<td>Veteran</td>
</tr>
<tr>
<td>Lewis</td>
<td>Mother, Father</td>
<td>New student</td>
<td>Junior</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Tristan</td>
<td>Mother, Father</td>
<td>New student</td>
<td>Graduate</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Wendell</td>
<td>Mother</td>
<td>New student</td>
<td>Graduate</td>
<td>Non-veteran</td>
</tr>
<tr>
<td>Zane</td>
<td>Mother, Father, Sibling</td>
<td>New student</td>
<td>Sophomore</td>
<td>Non-veteran</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Sex</th>
<th>What is your age?</th>
<th>Major</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Aerospace Engineer</td>
<td>Full time student</td>
</tr>
<tr>
<td>Chad</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Mechanical Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Connor</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Masters in Mechanical Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Darian</td>
<td>Male</td>
<td>31-39 years old</td>
<td>Masters in Mechanical Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Lewis</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Computer Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Tristan</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Masters in Mechanical Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Wendell</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Masters in Software Engineering</td>
<td>Full time student</td>
</tr>
<tr>
<td>Zane</td>
<td>Male</td>
<td>18-25 years old</td>
<td>Aerospace Engineer</td>
<td>Full time student</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name</th>
<th>Number of Engineering Design Competitions Experienced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adam</td>
<td>1</td>
</tr>
<tr>
<td>Chad</td>
<td>6</td>
</tr>
<tr>
<td>Connor</td>
<td>20</td>
</tr>
<tr>
<td>Darian</td>
<td>14</td>
</tr>
<tr>
<td>Lewis</td>
<td>3</td>
</tr>
<tr>
<td>Tristan</td>
<td>4</td>
</tr>
<tr>
<td>Wendell</td>
<td>6</td>
</tr>
<tr>
<td>Zane</td>
<td>3</td>
</tr>
</tbody>
</table>
APPENDIX E

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Title: An Examination of Functional Role Behavior and Its Consequences for Individuals in Group Settings:
Author: Peter E. Mudrack, Genevieve M. Farrell
Publication: Small Group Research (Behavior)
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Date: 11/01/1995
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Benedictine University
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Port Orange, FL 32128

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