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A Mixed Methods Study on Mid-Year Engineering Students' Perceptions of Their Future Possible Careers

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A MIXED METHODS STUDY ON MID-YEAR ENGINEERING STUDENTS' PERCEPTIONS OF THEIR FUTURE POSSIBLE CAREERS

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Abstract

In this doctoral work I seek to answer the research question: "In what ways are mid-year engineering students thinking about their future careers, and how are their perceptions related to their current academic actions and decisions?" I use a multi-phase mixed methods research design with a phenomenographic approach guided by theoretical frameworks of future time perspectives, future possible selves, and goal paths. In the five-phase study, the qualitative strands provide an in-depth understanding of the phenomenon, and quantitative strands allow for a broader exploration of the phenomenon across multiple majors and institutions.

Four different ways of thinking about the future possible careers were identified and described using an analogy of shapes of ice-cream cones: Sugar Cone—one well-defined ideal and attainable future possible career; Cake Cone—broad and optimistic perceptions of future possible careers; Waffle Cone—conflicting ideal and realistic future possible careers; and Cup—lack of future-oriented motivation with feelings of being stuck in engineering. These four ways of thinking about the future are further described by how the present and future connect, their relationship to different academic and social identity demographics, and shifts in these perceptions over time. These results provide a visualizable and memorable framework for understanding the variety of ways mid-year engineering students are perceiving their future possible careers, and they provide insight into how to create an inclusive classroom environment for different types of motivations.

Dedication

I receive my degree on May 9, 2019. Nine years ago, to the day, I was at a different point in my life, one where finishing this doctoral work seemed more like a fantasy I would never be able to achieve. It has been an unbelievable journey to reach this point. This dissertation is dedicated to my constant and unwavering support system.

Acknowledgments

I would like to acknowledge all of the love and support I have received, without which this doctoral work would not have been possible. Thank you to the National Science Foundation for all they do to support innovation and education in the sciences and for financially supporting this research (Graduate Research Fellowship ID #2016215077 and Grant # EEC-1055950). I would like to specially acknowledge the original creator of the ice cream cone analogy, so prevalent through my work—Adam Kirn. I hope to faithfully use this vision to make this research more accessible and memorable for the general public.

I want to acknowledge my advisor, Lisa, for being so supportive as I struggled to find my path and what I needed to do to be my best self. You have been my fierce champion, an incredible role model, and the best "research mamma" I could ever hope for. Thank you to my family who have been there to celebrate every victory and embrace me through every challenge; it has been a long journey with many ups and downs. Thank you to my doctoral committee for all of your guidance and many meetings. And finally, thank you Clemson and the ESED community who have been and will always be home for me.

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CHAPTER 1

INTRODUCTION

Future-Oriented Motivation and Philosophical Considerations

1.1 Study Overview

In this chapter, I will outline the specific purpose of this doctoral work and how it is positioned with respect to three key future-oriented motivation theoretical frameworks: Future Time Perspective, Future Possible Selves, and Contingent Goal Paths. I will also preview the methodological frameworks, describe my philosophical standing, and outline the layout of the dissertation chapters.

Purpose Statement

The purpose of this doctoral work is to identify the variety of ways engineering students are motivated by their future careers. Students' perceptions of their future and career goals influence their behaviors and decisions in the present, such as how

much effort to put into tasks for the classes they are taking in their major. In turn, those decisions and experiences influence their future perceptions and career goals (Kirn & Benson, 2018). This reciprocal dynamic describes a way of thinking about the future that varies even among students who are in the same class or for an individual student at different points in their academic career (Hilpert et al., 2012; Husman & Lens, 1999). Although future-oriented motivation is a well-established theoretical framework, there is a gap in the literature looking at mid-year engineering students, those in the most crucial point of their academic careers, particularly identifying a way to describe the variety of ways those students are thinking.

Describing these different ways of thinking about the future for engineering students can help researchers and instructors understand the variety of ways engineering students are perceiving the future and improve the educational experiences for these students by considering students' motivation for pursuing engineering. Further, exploring how those different perceptions shift at crucial points during a student's academic career, such as the sophomore and junior years when engineering students are most likely to leave engineering (Min, Zhang, Long, Anderson, & Ohland, 2011), will inform researchers, practitioners, and advisors working towards retaining those students whose career goals align with engineering, and help students who truly do not want to remain in engineering, discover sooner this mismatch between their goals and their major.

Research Questions

The guiding research question (RQ) for this study is: "In what ways are mid-year engineering students thinking about their future careers, and how are their perceptions related to their current academic actions and decisions?" The guiding research question is broken into four sub-questions:

> RQ 1: What are the characteristic ways mid-year engineering students are thinking about their future careers?
>
> RQ 2: How are mid-year engineering students' perceptions of their future careers related to their current academic actions and decisions?
>
> RQ 3: What is the relationship between students' characteristic ways of thinking about their future possible careers and their academic and social identity demographics?
>
> RQ 4: How do mid-year engineering students' perceptions of their future possible careers shift over the academic year?

These research questions encompass the future-oriented motivation theoretical frameworks of Future Time Perspectives, Future Possible Selves, and Contingent Goal Paths. The research question drives the need for a mixed methods approach with phenomenological underpinnings. The theoretical and methodological frameworks will be described in the following sections.

1.2 Future-Oriented Motivation Theoretical Foundations

Future Time Perspective

All students are motivated by their different future goals (Lens, Paixão, Herrera, & Grobler, 2012; Malka & Covington, 2005). These future goals, how they are integrated into the present, and how they affect actions in the present are a student's future time perspective (FTP) (Husman & Lens, 1999). Research has identified several constructs within FTP: extension (Daltry & Langer, 1984) or distance (Hilpert et al., 2012), speed (Hilpert et al., 2012), value or valence (Husman & Lens, 1999), future time attitude (Husman & Lens, 1999), density (Husman & Shell, 2008), connectedness (Husman, Hilpert, & Brem, 2016), and perceived instrumentality (Kauffman & Husman, 2004).

Extension refers to how far into the future a person is setting goals (Lens et al., 2012), and is more generally how far into the future a person is thinking (Daltry & Langer, 1984). One's extension can be short, where only the very near future is considered; or extension can be long, where psychological time extends into the distant future (Volder & Lens, 1982). Extension is also referred to as "Distance" in the literature (Hilpert et al., 2012). Valance is how much one values the future or thinking about the future (Husman & Lens, 1999). An increased valence for distant future goals has been found to be associated with an increased academic performance (Volder & Lens, 1982). Generally, the longer one's extension, the more valence will be placed on distant future goals (Husman & Lens, 1999). Future Time Attitude is one's time

attitude directed towards the future; one's future time attitude can be positive or negative in regards to thinking about the future (Daltry & Langer, 1984).

Density refers to the number of goals a person has set within a timespan (Husman & Lens, 1999). Speed at which one feels time passing is how quickly the future is perceived to be approaching (Husman & Lens, 1999). The quicker the future is approaching, the less in control of and overwhelmed by the future a person may be (Hilpert et al., 2012). This ability to anticipate the future is related to the cognitive aspects of future time perspectives, such as connectedness and perceived instrumentality (Husman & Shell, 2008).

How connected the future is to the present, or Connectedness, is the extent to which a person believes they have control over the future (Husman & Lens, 1999). Connectedness, one of the cognitive aspects of FTP (Husman & Shell, 2008), is highly related to perceived instrumentality (Simons, Dewitte, & Lens, 2004). Perceived Instrumentality, how useful the person perceives a certain task to be in regards to their future goals, is the cognitive (Husman & Lens, 1999) and more task specific dimension of FTP (Lens et al., 2012). One perceives a task that is related to the future long-term goal as a step necessary to reach that goal as having *exogenous* perceived instrumentality (Husman, Derryberry, Crowson, & Lomax, 2004). A task that is enjoyed or desired because of the task itself is described as having *endogenous* perceived instrumentality to an individual (Husman et al., 2004; Husman & Lens, 1999).

Future Possible Selves

When thinking about the future, a person creates future possible selves, or a cognitive manifestation of their hopes, dreams, and fears for the future (Markus & Nurius, 1986). Future possible selves are the cognitive conceptions of who they believe they can become (realistic or achievable selves), who they want to become (ideal or hoped-for selves), and who they do not want to become in the future (avoided or feared selves) (Aloise-Young, Hennigan, & Leong, 2001; Markus & Nurius, 1986; Oyserman, Bybee, Terry, & Hart-Johnson, 2004). Future possible selves is the link or incorporation of future goals and the self-concept, where future possible selves can serve as a roadmap for attaining future goals Markus & Nurius, 1986; Oyserman, Brickman, & Rhodes, 2007).

A person's hoped-for or ideal future possible self is who they ideally want to become in the future. A realistic future possible self describes who a person believes they can be in the future; a feared or avoided future possible self describes who a person does not want to be in the future (Husman & Lens, 1999; Markus & Nurius, 1986). These ideal, attainable, and avoided possible selves are typically discussed as expected futures, or beliefs about the future (Oettingen & Mayer, 2002). Expected futures are the futures a person is actively working towards, as opposed to impossible future selves. Research has also been done on Impossible Future Selves, or future possible selves that seem unachievable, and the decisions students make in the present to adjust their future possible selves when faced with an obstacle or major change

(Pizzolato, 2007). These different possible selves may be balanced, where a hoped-for future possible self is accompanied with a feared self in a similar context (i.e. hoping to become a surgeon but avoiding becoming a family practitioner) (Aloise-Young et al., 2001).

In this work, we will be discussing future possible careers. A person's future possible career is an aspect of a person's future possible selves that describes their cognitive manifestations of who they can become, want to become, and do not want to become in terms of their careers (McGough, Orr, Kirn, & Benson, 2018).

Contingent Goal Paths

Students are who are actively working towards their realistic future possible selves, take steps in the present to reach those goals. The series of steps, or sub-goals, create a path to reach their distant future goal (Miller, 1999), related to their future possible careers; this path is known in the literature as a contingent goal path (Oettingen & Mayer, 2002). Contingent goal paths are the set of dependent goals needed to reach distant future goals (Raynor, 1969). For example, an engineering student may have a distal future goal of working for an automotive company and a sub-goal for that distal future goal may be graduating with a Mechanical Engineering degree. That student may define several sub-goals and create a series of steps needed to reach that distant future goal. Such steps that are dependent on one another form contingent goal paths (Miller, 1999).

These different constructs in future time perspective, future possible careers, and contingent goal paths are all closely related in this doctoral work. It is important to consider contingent goal paths when understanding how a student perceives the future as being connected to the present (connectedness); a student who views a task in the present as being connected to or important to the future the present will perceive that task to have a higher perceived instrumentality. A student may find a task to be more useful when it is related to a sub-goal on a contingent path (Miller, 1999).

1.3 Methodological Foundations

Mixed Methods

Mixed methods research is becoming known as one of the three major research paradigms: quantitative, qualitative, and mixed methods research (Creamer, 2018). The definition of mixed methods research has had some debate; Johnson, Onwuegbuzie, and Turner (2007) list the many different definitions of mixed methods research from responses by leaders in the field. Mixed method research was defined in this doctoral work using one of those many definitions, specifically as defined by researcher, Huey Chen:

> Mixed methods research is a systematic integration of quantitative and qualitative methods in a single study for purposes of obtaining a fuller picture and deeper understanding of a phenomenon. (Johnson, Onwuegbuzie, & Turner, 2007, p. 119)

The key aspect in this definition is the purposeful use of quantitative and qualitative methods in the planning and implementation of a study to answer a research question that otherwise could not be answered fully by quantitative or qualitative methods alone.

In the 1980's, mixed methods began to be recognized as a key methodology, or a framework providing guidelines for practice, methods, and philosophical assumptions (Creamer, 2018). The main philosophical assumption present in mixed methods research is that quantitative and qualitative methodologies are compatible and produce more robust findings, increase validity and offset weaknesses inherent in either method (Onwuegbuzie & Johnson, 2006). This combination is sometimes referred to as *methodological eclecticism*, where the most appropriate techniques from quantitative and qualitative methods are creatively integrated to address the research question (Teddlie & Tashakkori, 2012). This philosophical assumption also adopts *paradigm pluralism*, where multiple paradigms are adopted within one study. The philosophical assumptions and paradigms of this doctoral work is discussed further on pg. 15. In this doctoral work, the term "methodology" may be used rather than "methods"; the key difference is that a methodology is "a coherent framework of philosophical assumptions, methods, guidelines for practice, and sociopolitical commitments" (Creamer, 2018, p.5).

Although there are multiple definitions of what mixed methods research consists of, each definition includes a combination of quantitative and qualitative methods that

are integrated or "mixed." A study that combines multiple methods that are all quantitative or qualitative is described as multimethods research (Creamer, 2018). A study using quantitative and qualitative methods without mixing is described as quasi-mixed methods (Teddlie & Tashakkori, 2009).

The qualitative and quantitative methods in a mixed methods study are referred to as "strands." Quantitative methods address the "what" and "why" of a research topic, are variable oriented, and offer breadth to the context of the study, while qualitative methods address the "how" of a research question and offer depth to the study (Creamer, 2018). In pure form mixed methods, which this study adopts, the quantitative strands of the study maintain the original procedures of quantitative methods, and the qualitative strands of the study maintain the original structure and procedures of qualitative methods (Creamer, 2018; R. Johnson et al., 2007). Alternatively, these two methods can be altered to fit the needs of the study (modified form mixed methods) (Johnson, Onwuegbuzie, & Turner, 2007), fitting with the problem-focused and pragmatic approach of mixed methods research (Cresswell & Clark, 2011a).

Mixing is a defining aspect of mixed methods research, and is defined as "the linking, merging or embedding of qualitative and quantitative strands of a mixed methods study" (Creamer, 2018, p. 5). There are many different frameworks for describing mixing; one of the most commonly cited is Greene, Caracelli and Graham's (1989)

types of mixing, described as purposes for mixed methods designs (Bryman, 2006; Greene et al., 1989). In this paper the following types of mixing were utilized:

> *Development* seeks to use the results from one method to help inform the other method, including sampling, measurement decisions, and implementation.
>
> *Triangulation* seeks corroboration of results from the different methods, to increase the validity of constructs and results by counteracting biases inherent in either method.
>
> *Complementarity* seeks elaboration or clarification of results from one method with results from the other method, to increase the interpretability of the constructs and results.
>
> *Expansion* seeks to extend the breadth of inquiry by using different methods for different inquiry components, to increase the scope of inquiry.

The ways in which and the stage in which methods are mixed vary in mixed methods. In fully integrated mixed methods research, the researcher has single holistic perspective throughout all strands of the study. Integration was designed to occur at each phase of a study—design, data collection, sampling, data analysis, and inferences—which requires flexibility throughout the study in terms of the contribution of quantitative and qualitative data. Meta-inferences, unique to mixed methods research, are the inferences that result from the combined interpretation of qualitative and quantitative results (Creamer, 2018).

Phenomenography

Phenomenography is a qualitative research method that stemmed from the need to answer recurring questions in education research about how students learn (Marton, 1986). Phenomenography originated in the early 1970's (Dall'Alba & Hasselgren, 1996); the first research study identified as having a phenomenographic nature, in that the results cannot be separated from the phenomenon, focused on how learning content and learning itself was conceived by the students (Dall'Alba & Hasselgren, 1996). The term *phenomenography* became known as the methodology that maps the qualitatively different ways in which people conceive, conceptualize, perceive, experience, and understand phenomena in the world (Dall'Alba & Hasselgren, 1996; Marton, 1981, 1986). Phenomenography started with the focus of student learning and has since come to be known to include not only learning, but also education in general as well as other contexts (Marton, 1988).

In engineering education, phenomenography has been used primarily to identify the different ways students understand key concepts, such as computer science in engineering and conceptions of energy in chemical engineering solution processes (Case & Light, 2011; Ebenezer & Fraser, 2000). However, as the field of engineering education continues to grow, phenomenography is being used to answer different questions, such as describing the ways in which students experience learning in groups (Booth, 2001), experience human-centered design (Zoltowski, Oakes, &

Cardella, 2012), and experiences of first-year engineering students working in teams to solve ill-structured problems (Dringenberg & Purzer, 2018).

The ultimate goal of phenomenography is to faithfully identify and describe the participants' perceptions of their experience of the phenomenon in a specific context (Sandberg, 1996). Four features of phenomenography are described as relational, experiential, contextual, and qualitative (Marton, 1986, 1988). Phenomenography has a relational aspect in that the focus is on a second-order perspective of "man's *relationship* with the world" (Dringenberg, Mendoza-Garcia, Tafur, Fila, & Hsu, 2015; Marton, 1986). Phenomenography is experiential in that it is not concerned with aspects of the phenomenon, but rather the different ways in which people *experience* the phenomenon (Marton, 1988). Phenomenography is contextual in that the results cannot be separated from the context of the phenomenon, and is qualitative and descriptive (Dringenberg et al., 2015).

Quality Considerations

The quality of this research is based on multiple theories of qualitative quality (Walther & Sochacka, 2015) , scale development (DeVellis, 2012), and mixed methods legitimation (Onwuegbuzie & Johnson, 2006).

The qualitative quality is described through the Qualifying Qualitative research Quality (Q3) framework, which defines six types of validity and reliability to consider in the making and handling of the data: theoretical validation, procedural validation,

communicative validation, pragmatic validation, ethical validation (Sochacka, Walther, & Pawley, 2018), and process reliability (Walther & Sochacka, 2014; Walther, Sochacka, & Kellam, 2013). These consider 1) the fit between the social reality and the theory being produced, 2) the procedures incorporated in the study design to improve this fit, 3) the co-construction of knowledge within the study and the research community, 4) the extent to which the theories being used are compatible with the reality, 5) the integrity and responsibilities of the researchers throughout the study, and 6) the overall validity and avoidance of the influence of random variables in the study (respectively).

The validity and reliability of the quantitative strands are considered in the development of the survey instrument as well as continued testing of the instrument. In survey instruments, constructs are being measured through several items making up a factor. A reliable instrument performs in consistent and predictable ways, with numerical values representing a true state of the construct being assessed (DeVellis, 2012). Validity ensures that the variable being measured is the actual cause of any covariance between items (DeVellis, 2012). Such validity and reliability considerations include construct validity, content validity, internal consistency reliability, and external validity. Construct validity measures how well the instrument behaves as expected compared to established measures of other constructs. Content validity measures how well the set of items reflect the content of a theory or construct. Internal consistency reliability measures how correlated the items in a

factor are, can suggest that the items in each factor are measuring the same construct (DeVellis, 2012). External validity measures how well the results of the instrument can be generalized or replicated with other methods (Calder, Phillips, & Tybout, 1982).

Mixed methods research studies present a number of challenges to the researcher. Mixed methods studies require extensive time commitments, and the researcher must be adept at both quantitative and qualitative research (Cresswell & Clark, 2011a). For this reason, I consider the quality of my mixing of methods using Onwuebuzie and Johnson's (2006) framework for validity in mixed methods research called "legitimation"(Onwuegbuzie & Johnson, 2006). Legitimation includes considerations such as *sample integration*, the integrity of the meta-inferences resulting from the relationship between the quantitative and qualitative samples; *weakness minimization*, or the compensation of the weaknesses in one method by the strengths of another; and *paradigmatic mixing,* or the effective blending of the underlying philosophical beliefs underlying quantitative and qualitative approaches.

1.4 Philosophical Standing

The researchers' philosophical standing (worldview, ontology, and epistemology) influences methodological decisions, analysis, and how the results of a study are presented. Therefore, it is important for me to define my philosophical standings for the reader to understand the underlying assumptions in this research.

My worldview as a researcher is primarily pragmatist, with a leaning towards constructivist. Traditionally, mixed methods research maintains the worldview of pragmatism (Creswell, 2014). Pragmatism is not committed to any one ontology or epistemology; with a pragmatist worldview, the researcher draws from both quantitative and qualitative philosophies as needed to answer the research question (Cresswell & Clark, 2011a). In a constructivist worldview, the researcher believes that individuals construct reality through their understanding, perceptions, and meaning of experiences they have; there are multiple realities that are subjective and shaped by individuals. I find that quantitative research reconciles well within the constructivist worldview, where the survey instruments used are intended to capture individuals' realities, understandings. The perceptions, or results, are interpreted with the understanding that there may be multiple realities.

My researcher ontology, or assumptions about the nature of the social world (Greene, 2008), throughout this study primarily draws from the phenemonographic traditions and mixed methods research traditions. I wish to faithfully describe the participants' perceptions and experiences, which reconciles with both the phenomenographic and mixed methods traditions (Sandberg, 1996). Following the phenomenographic ontological perspective of non-dualism, reality cannot be separated from the experience of reality (Barnard, McCosker, & Gerber, 1999; Marton, 1981), this research is not concerned directly with aspects of the phenomenon, but rather the experience of the phenomenon. While phenomenography is descriptive and

qualitative (Dringenberg et al., 2015), the pragmatic ontological perspective of mixed methods research calls for the need of quantitative data to answer the research question and explore the phenomenon in a broader population than phenomenography traditionally describes.

In a phenomenography, the context is crucial to getting an in-depth understanding of a narrow target population. An underlying assumption and ontological perspective of phenomenography is that there is a finite number of ways that a phenomenon is experienced; saturation can be reached when no new perspectives of the phenomenon are found in the analysis. The small target population is necessary for reaching saturation. However, expanding the population was crucial to informing practitioners and to address the purpose of this study, which fits within the ontological perspective of pragmatism. Pragmatism is problem oriented, with a focus on implementing whichever methods are needed to answer the research question; the pragmatist ontological perspective states that there can exist both singular and multiple realities (Cresswell & Clark, 2011a).

The researcher epistemological stance, or assumptions about the nature of warranted social knowledge (Greene, 2008), defines the relationship between the researcher and the data. My epistemological stance is that of practicality. Throughout the quantitative research methods, I strive to retain objectivity while keeping the research questions in mind. Throughout the qualitative and mixed methods, my

interpretation of the data does inform how I present the results, but primarily I strive to faithfully describe the participants' perceptions and experiences.

A Note on Tense

Following the tradition in mixed methods research, I describe the quantitative aspects of the study in the passive voice to represent the more objective making and handling of the data, and the qualitative and mixed points of the study in the active voice to emphasize my role as the researcher in the design and execution of the methodology.

This dissertation is a compilation of my work as a researcher; however, it is my belief that all scholarly pursuits have some collaborative aspect, as knowledge is socially constructed. I will use both "I" and "we" throughout this dissertation, to give credit to myself and the members of the research group that I worked with at the appropriate points.

1.5 Outline of Chapters

In this dissertation, I present the overview and background for my doctoral work in Chapter 1. Chapter 2 will focus on the research design of the entirety of the doctoral work, including detailed methods for the multiple phases or sub-studies. In the following chapters, Chapter 3 through Chapter 7, I will describe the results and discussion of the individual phases of this work. In Chapter 8, I will present meta-inferences through mixing and interpreting the results of each of the phases and

answer the research questions, and in Chapter 9 I will summarize the findings of this doctoral work, consider the broader implications of the totality of the work, and ideas for future directions in this research area.

CHAPTER 2

DETAILED RESEARCH METHODS

Multi-Phase Mixed Methods Research Design

2.1 Overview

In this dissertation, I present a multi-phase mixed methods study (Cresswell & Clark, 2011a) which uses both quantitative and qualitative methods to understand the phenomenon of how mid-year (second and third year) engineering students at research institutions are thinking about their future careers and how those perceptions relate to their current academic actions and decisions. To gain a deeper understanding of the phenomenon and answer the research questions, the quantitative strands of the study maintain the original procedures of quantitative methods, and the qualitative strands of the study maintain the original structure and procedures of qualitative methods (Johnson, Onwuegbuzie, & Turner, 2007, p. 119).

2.2 Research Design

In this study, I use a multi-phase mixed methods research design to address the guiding research question: "In what ways are mid-year engineering students thinking about their future careers and how are their perceptions related to their current academic actions and decisions?"

The study consists of an exploratory qualitative phase (Exploratory QUAL Phase), survey development phase, an exploratory quantitative phase (Exploratory QUAN Phase), a follow-up quantitative phase (Follow-Up quan Phase), and an explanatory qualitative phase (Explanatory QUAL Phase), which occur sequentially in that order, with mixing (developmental, complementarity, and expansion) at multiple points (Greene et al., 1989). Each phase will answer a separate research question, while also contributing to the research questions of this doctoral work. The research questions for each phase will not match exactly the research questions for the overall study. A visual explanation of how the research questions for the doctoral work (Chapter 1, pg. 3) are addressed by the phases is shown in Table 2.1.

Note that in mixed methods research the shorthand for quantitative methods is 'quan' and for qualitative methods is 'qual.' The capitalization of quan and qual has meaning; all uppercase indicates the methods are prioritized in the design of the study, while lowercase indicate supplemental methods (Cresswell & Clark, 2011b, pg. 109).

Table 2.1 Research Questions Answered by Each Phase

	Exploratory QUAL	Survey Development	Exploratory QUAN	Follow-Up quan	Explanatory QUAL
RQ 1	X	X	X		X
RQ 2	X	X	X		X
RQ 3		X	X		X
RQ 4		X		X	X

The Exploratory QUAL Phase is a phenomenographic study identifying the different ways mid-year biomedical (BME) and mechanical (ME) engineering students at one institution think about their future careers. During the Survey Development Phase, we use the initial qualitative findings to develop an instrument that can quantitatively identify these different ways of thinking about future careers. The Exploratory QUAN Phase involves a multi-institution survey distribution in which we explore the phenomenon of thinking about future careers for students in large-enrollment sophomore civil (CE) engineering, electrical (EE) engineering, and ME courses. The design of Follow-Up quan Phase is primarily for participant selection that arose from the need for an Explanatory QUAL Phase to explore in more depth new findings from the Exploratory QUAN Phase. This sequence of phases is represented visually in Figure 2.1; a more detailed diagram with a timeline is included in Appendix A.

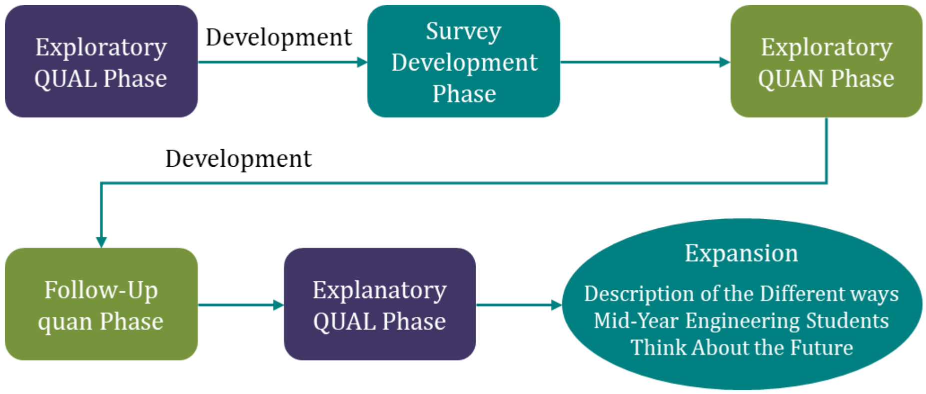

Figure 2.1 Diagram of Multiphase Mixed Methods Design. Shading differentiates between qualitative (purple), quantitative (green), and mixing (blue) methods. Arrow lines indicate sequential methods.

Target Population

The target population for this study is mid-year engineering students (defined here as sophomore, or second-year, and junior, or third-year, students) in large-enrollment classes at large research institutions. These students were deemed to benefit the most from the results and practical implications of this study and future studies continuing this research. Students' motivations in large-enrollment courses are perhaps the least understood because their instructors do not have the resources to get to know the students' motivations, particularly at large research institutions, where research often is prioritized over teaching. In this study, large-enrollment is defined according to a cutoff indicated the Princeton Review (The Princeton Review, 2017) of classrooms with a student to instructor ratio larger than 50:1.

Additionally, mid-year students were targeted because engineering students are most likely to leave engineering in their third through fifth semesters, or sophomore

year and first semester junior year (Min et al., 2011). For the purpose of understanding students' perceptions of their future career, mid-year students are ideal since they have started their discipline specific courses and their futures beyond graduation are not yet in the near future, as it may be for senior students. Additionally, mid-year level courses typically have larger class sizes than the senior level technical courses.

Participants in this study were recruited through six institutions designated as Universities A through F, as detailed in Appendix B. The participants for each phase are described in a section at the beginning of the corresponding results chapter (Chapter 3-7).

Quality Considerations

Research quality in this study is ensured through methodological consistency, where quality is demonstrated by adherence to the philosophical and methodological assumptions of a method (Creamer, 2018; Cresswell, 2007). The quantitative and qualitative phases of this study stand alone as individual studies, each addressing their own research questions, and each retains the original procedures of traditional quantitative and qualitative methodologies in keeping with their underlying philosophical and methodological assumptions. Quantitative measures of reliability and validity, the Qualifying Qualitative research Quality (Q3) framework (Walther & Sochacka, 2014), and the legitimation of mixed methods framework (Onwuegbuzie &

Johnson, 2006) are used to ensure the quality of this study (Detailed in Chapter 1, pg. 13).

It is important to note the current events at the time of this study provide context to the data. The data was collected during Spring and Fall semesters in 2014, Spring and Fall semesters in 2015, Fall of 2016, and Spring and Fall semesters of 2017. During 2016 and 2017 there were some divisive issues in transgender rights, gun control, and environmental protection that influenced the tone of the interviews and survey responses. These events were noted and discussed by the researchers of the influence they may have had on the data and data analysis.

2.3 Exploratory QUAL Phase

In the Exploratory QUAL Phase, I address the research question: "What are the different ways mid-year engineering students are perceiving their future career goals and how those perceptions interact with their actions in their present engineering coursework?" This study is uses a phenomenographic approach, where the phenomenon the students are experiencing is thinking about their future career goals, and the context in which the students are experiencing the phenomenon is their current engineering coursework and the attainment of their engineering degree.

Participant Selection

The participants in this study were 18 mid-year BME and ME at University E. The selection of students from two similar majors at a single institution provided

variations in experiencing the same phenomenon, thinking about their future career goals in a similar context, engineering coursework and the attainment of their engineering degree (Dringenberg et al., 2015). ME and BME students experienced the phenomenon in a similar context in terms of engineering coursework, as many of the core courses that mid-year students take are similar in the BME and ME programs at this institution based on information in the undergraduate student catalog at that institution. While ME is considered a more traditional engineering major because it is older, larger and more well known, BME is considered more of an interdisciplinary major and is relatively newer. BME undergraduates usually plan on attending graduate or professional school after graduation. ME undergraduates usually plan on working in industry immediately after graduation (Kirn, Faber, & Benson, 2014).

The number of participants was influenced by balancing the need for adequate data to identify variations within it, the goal of reaching saturation (a point at which no further insights or perceptions about the phenomenon are revealed), and the practical constraint of working with a manageable amount of data (Yates, Partridge, & Bruce, 2012). A detailed description of the participants in this phase is included in Chapter 3 (pg. 57). A brief description for all interview participants in this doctoral study is included in Appendix C.

Data Collection

Following the phenomenographic tradition, we conducted semi-structured interviews (Dall'Alba & Hasselgren, 1996; Marton, 1986), which were audio recorded

and transcribed. I was the primary interviewer for half of the interviews; members of the research team were the primary interviewers the other half of the interviews and served as second interviewers for all interviews. In these interviews, the primary interviewer led the interviewee through a series of prompts with clarifying follow-up questions to explicitly reflect on the phenomenon of interest (Åkerlind, 2012), thinking about their future career goals. Data collection occurred over the course of three semesters (Spring and Fall 2014, and Spring of 2015). The interviews started with the question, "What are your goals for the future?" The interviewer then guided the students through different aspects of their future goals (career, ideal, avoided, relevant skills) with a range of follow-up questions, while the second interviewer took notes and asked any questions missed by the first interviewer. In this way, the second interviewer helped maintain consistency across each of the interviews.

The semi-structured interview protocol, detailed in Appendix D, consisted of three parts: long-term goals (perceptions of their future careers), short-term goals (academic behaviors and decisions), and interactions between short- and long- term goals (relevance of their education to their future careers). Interviews ranged from 39 to 95 minutes in length. Our research team piloted the interview protocol in another study with two upper-level engineering students who have experienced the phenomenon of interest in a similar context to the participants of this study; the interview protocol was refined to better capture the phenomenon of thinking about

future career goals. For more details on the development of the interview protocol, refer to Kirn and Benson (2018).

Data Analysis

The interviews were professionally transcribed; then I and another researcher listened to each audio recording while simultaneously reading the interview transcripts for accuracy, allowing us to be immersed in the data. The researchers used parts of the transcript that have the four primary characteristics of phenomenographic research: relational, experiential, contextual, and qualitative (or descriptive) (Barnard et al., 1999; Marton, 1988). The bounds of the conceptual framework were set by researchers aided by previous work (Kirn & Benson, 2018) and content experts. We developed an initial codebook with broad themes around the conceptual framework created with the analysis of the first nine interviews and used this codebook to code the subsequent nine interviews.

These broad, emergent themes are overarching concepts such as "the student describes how their future goals are influencing what they do in the present." Over each iteration, the identified themes became more focused on emerging aspects that are significant in distinguishing similarities and differences in the interviews (Åkerlind, 2012). As analysis continued, researchers refined the initial codebook into a more detailed codebook, using a more thematic deductive approach to coding (Saldana, 2013). Some of the qualitative descriptions from the analysis did not fit within these codes or needed more definition to distinguish different codes; we

marked these qualitative descriptions and re-examined to create new codes and further develop the codebook. The finalized codebook broke the major themes into differentiated codes with definitions of those codes, and example quotes that would be labeled as that code. The codebook is included in Appendix E.

RQDA, a qualitative coding tool, was used to mark text in the transcripts of the participants that fit within a code in the detailed codebook (Huang, 2016). An example of how the qualitative coding software was used is included in Appendix F. We created a summary page for each participant that described the key points of the participant's experience of the phenomenon based around the structure of the codes in the refined codebook. Research team members met to discuss the similarities and differences in these summaries, and to develop initially hypothesized groups based on these comparisons. Multiple researchers examined these proposed groups and discussed in-depth where participants fit into groups. During these conversations, no new groups emerged from descriptions, but rather only slight variations were clarified within each group.

The final result was a set of groups that are described in a consistent outcome space, focused around the final themes (Barnard et al., 1999). The description and definition of these groups were based on the discussions among the researchers in the research team, and the descriptions were narrowed to abbreviated descriptions based on important concepts for each group, which are presented as results in this paper.

Quality Considerations

The robustness of the methodological foundations of phenomenography helped us ensure the validity and reliability of the results. For example, commonly accepted research procedures for phenomenographic data collection and analysis helped ensure procedural validation, or incorporating features into the research design to faithfully capture the participants' reality (Walther & Sochacka, 2014; Walther et al., 2013). In making the data, semi-structured interviews allowed for the interviewer to guide the discussion to the phenomenon being studied while allowing participants the opportunity to express the full range of their experiences. Interviewers were careful to not interrupt or cutoff the participant, and to ask follow-up clarifying questions to ensure that we fully understood the participants' descriptions.

Also, I memoed throughout the study and interviews to acknowledge any biases I perceived during the analysis to ensure that the outcomes of this study were descriptions of the range of experiences within the sample group and not influenced by the bias of individual researchers (Åkerlind, 2012). Example memos from the qualitative strands of this study are provided in Appendix G.

If there were any questions about the intended meaning of interview transcript data, I contacted via email for follow-up questions to get confirmation, or I did not include the data in question. These methods work towards meeting theoretical validation, or ensuring the fit between the reality of the participant and the theory produced, by ensuring that the final groups resulting from the analysis were descriptions of the

range of experiences within the sample group and not influenced by the bias of individual researchers (Åkerlind, 2012; Walther & Sochacka, 2014).

2.4 Survey Development Phase

My purpose in the Survey Development Phase was to refine an instrument to quantitatively measure characteristics identified from the Exploratory QUAL Phase. Using an instrument in research that does not assess what the researchers are presuming to measure can lead to incorrect results and wrong decisions (DeVellis, 2012). We refined a pre-existing instrument, the Motivations and Attitudes in Engineering (MAE) survey (Benson, Kirn, McGough, Faber, & Chasmar, n.d.). To develop and refine the survey instrument, we developed items and tested for validity and reliability of the instrument.

Development of Items

Survey development occurred after the Exploratory QUAL Phase, in Fall 2015. I chose factors for the survey instrument based on the results from the Exploratory QUAL Phase. Then, I identified the code categories from the qualitative work that were needed to characterize the different groups described in the Exploratory QUAL Phase (Chapter 3, pg. 64). I created an initial pool of items and reviewed the code categories and refined these items with my research group. The items for this survey were taken from MAE survey and developed from the Exploratory QUAL Phase, to create a list of items to choose from, with at least five items for each factor (Benson et al., n.d.).

When developing items, there are some characteristics that distinguish "good" items from "bad" items, and these characteristics are mostly related to the clarity of the item (DeVellis, 2012). Keeping this distinction in mind I consulted with the research team to check the newly developed items for their clarity in terms of readability, unnecessarily lengthy items, research terminology, items asking multiple questions, or ambiguous items (DeVellis, 2012). Using this process, we narrowed down the item pool was narrowed down to about five items per factor that reflected the scale's purpose.

Validity and Reliability Testing

After the items were developed, they were tested for content validity, or how well the items reflect the intended factors (DeVellis, 2012), using feedback from experts in the field and focus groups with the target population of sophomore undergraduate engineering students. We shared the item pool with four experts in the field of future-oriented motivation and survey development; these experts made suggestions as to how to improve the items.

I conducted focus groups (*n=3* focus groups, *n=6* participants) using the target population of sophomore engineering students. In these focus groups, I asked students to fill out the survey rating the *clarity* of the items. I then interviewed the participants together in a group of one to three participants, about how they interpreted the items, what items were unclear, and why those items were unclear.

We changed the items accordingly and had the revised items reassessed by the experts to develop a final list of items.

We compiled the final list of items into a survey instrument, which also included demographic information and an option to volunteer for a follow-up interview. The survey was given for course credit to a sophomore level IE course, and 187 students completed the survey. I cleaned and analyzed the data using a statistical software package, R (R Core Team, 2016); R is used for all quantitative analysis in this study. The scree plot generated within the factor analysis was used to determine the number of factors that best explain the variability in the data. An exploratory factor analysis (EFA) was run with six factors, to test if the items would factor into the intended constructs, and then run with the number of factors indicated by the scree plot (Catell, 1966) .

Those factors were then tested for internal consistency reliability. A high internal consistency reliability, or how correlated the items in a factor are, can suggest that the items in each factor are measuring the same construct (DeVellis, 2012). Cronbach's alpha (α) was used to test for internal consistency reliability for each of the factors. For every instance of α in this study, an $\alpha > 0.7$ is considered acceptable.

A k-means cluster analysis and interviews were used to test for external consistency, or how the results of the instrument can be generalized or replicated with other methods (Calder et al., 1982). A k-means cluster analysis forms homogenous groups

based on the scores from the specified factors (Fraley & Raftery, 1998). The results from this analysis indicate if students are grouping into clusters representing characteristic ways of thinking about their future possible careers. Additionally, we conducted interviews (*n=3*) using the semi-structured interview protocol that was implemented in the Exploratory QUAL Phase. We analyzed the transcripts from the interviews using *a priori* coding, where the codes, or themes, from the Exploratory QUAL Phase were used to describe each of the students in terms of the groups identified in the previous phases. We then compared the results from the cluster analysis and the interview analysis to check how well the instrument was capturing the characteristics we can identify in interviews.

2.5 Exploratory QUAN Phase

The purpose of the Exploratory QUAN Phase is to gain insight on how mid-year engineering students, in majors and institutions beyond those explored in the previous phases, are thinking about their future careers and how those different ways of thinking may or may not be related to academic and social identity demographics. This phase answers the research question, "What are the quantitatively different ways mid-year engineering students are thinking about their future possible careers, how are these characteristic ways of thinking distributed, and are the characteristic ways of thinking about the future related to academic or social demographics?"

Participant Selection

The target population for the Exploratory QUAN Phase were students in large-enrollment courses, specifically sophomore level, CE, EE, and ME courses at research institutions. Three of the traditional engineering majors, CE, EE, ME, have the most degrees awarded (Yoder, 2016), and potentially the most students in introductory courses.

Data Collection

Instructors of CE, EE, and ME large-enrollment sophomore courses at large research institutions were contacted via emails. The emails (shown in Appendix H) provided a short description of the study, explained their role in the study (email the survey link to all of their students, and either provide an incentive or provide ten minutes of class time to complete the survey), and were offered a summary of the results from their classroom describing their students' perceptions of the future and how they thought the course connected to their future careers. Some instructors were recruited via networking with flyers distributed at conferences. The flyer is provided in Appendix I.

If the instructor agreed to participate, the institution review board (IRB) or research ethics board of the participating institution was contacted to ensure that the instructor was not considered engaged in the research and IRB approval was not necessary, thereby removing any extra strain on the instructors. One or two days

before the survey was scheduled to be distributed, the instructors received an email that they could forward to their students; this email is provided in Appendix J.

Students were given a link to the electronic survey by their instructors; the survey instrument is described in detail in Appendix K. Data collection occurred two weeks into the semester, over two semesters: Fall 2016 and Spring 2017. Students had access to the survey for two weeks, and after one week received a reminder from their instructor. The 12 instructors for 12 courses at 5 institutions agreed to distribute the survey.

The distribution method varied according to the IRB restrictions at each institution; instructors at some institutions could introduce the study in class and provide an incentive for completing the survey, while other instructors were only able to forward the email with the survey link without introducing the study to the class. The distribution method impacted the response rate for these classes. A description of the courses, number of students, and distribution method used at each of these institutions is provided in Appendix L.

Data Cleaning

Prior to any analysis, the data were cleaned to protect the participants. Anyone who identified as under 18 years old (*n=7*) or did not consent for their data to be used in the study (36) were removed from any analysis. Some participants completed the survey multiple times; duplicates were identified by matching email addresses (5)

and by full names and demographics (1). All duplicates were then removed from analysis. Next all participants were assigned study IDs and all identifiers were removed. Participants who did not fill out any items (2) or who answered the same number for every item, including the reverse coded items (1) were also removed.

Quality Considerations

Because the survey has been tested for validity and reliability on participants from a different, yet similar, population in the Survey Development Phase, the validity and reliability of the instrument was tested before further analyzing the data, not only to ensure quality of the data in this phase but also to help refine the survey instrument for future studies. Cronbach's alpha and the covariance matrix was used to test the internal consistency reliability of the factors (DeVellis, 2012). The highest covariance should be lower than the lowest alpha, and an acceptable cutoff for alpha was >0.7 (Cho & Kim, 2015). A confirmatory factor analysis (CFA) was performed to test for construct validity, or how well the constructs of the instrument fit with the established ways in which the constructs should behave (Curran, West, & Finch, 1996; DeVellis, 2012; Gagne & Hancock, 2006). CFA is used when the researchers have a hypothesized model for how the items fit within factors; CFA measures how well the proposed model fits the data (Fabrigar, Wegener, MacCallum, & Strahan, 1999; Wegener & Fabrigar, 2000). Model fit measures how well the proposed model accounts for the covariance between the items. If the model is inconsistent with the data, the statistical test will indicate a poor fit based on cut-off measurements (CFI

and TLI <0.95, RMSEA and SRMR <0.08) or a more relative cutoff comparing these statistical measurements between the proposed model and a one-factor model. The Root Mean Square Error Approximation (RMSEA) is related to the residuals in the model. Values for RMSEA range from zero to one, with smaller values indicating a better model fit a general. Acceptable model fit is indicated by a value of 0.1 or less (Thompson, 2004) and a good model fit is indicated by a value of 0.08 or less (Browne & Cudeck, 1993). CFI and TLI indices are also commonly used to asses fit, with a general cutoff rule of <0.95.

When running a maximum-likelihood CFA, there is a strong assumption of multivariate normality (Curran, West, & Finch, 1996). To test this normality assumption, a check for skew and kurtosis was run (Johnson, Tietjen, & Beckman, 1980; Westfall, 2014). A maximum normalized skew of |2.0| and a maximum kurtosis of 7.0 are considered to fit within the bounds for the assumptions of normality (Johnson et al., 1980). Skew measures the symmetry of the distribution; if the data is distributed evenly, or has a normal distribution, skew is equal to zero (Mardia, 1970). Kurtosis is a measure of normality that describes the extremities of the tails of a unimodal distribution curve (Westfall, 2014). The kurtosis for a normal distribution is equal to three; however, kurtosis is often normalized by statistical software to zero for a normal distribution. When referring to kurtosis throughout this paper, it is the normalized kurtosis of zero.

Data Analysis

To identify characteristic ways these students are thinking about their future career, cluster analysis was used to identify groups of students with similar responses on three factors: Clarity of Future Possible Careers (Clarity), Alignment of Future Possible Careers (Alignment), and Perceptions of The Future in Engineering (Future in Engineering). Several clustering methods were considered—Ward's, Partitioning Around Medoids, Median and Centroid Hierarchical, and k-means (Flynn, 2000; Fraley & Raftery, 1998). K-means best fit the data; k-means cluster analysis is appropriate for large sample sizes where the number of clusters is hypothesized based on theory or previous studies, so it is the appropriate clustering method for this study (Flynn, 2000; Fraley & Raftery, 1998). Based on prior work, there were three anticipated clusters and factor means. However, the prior work was not a multi-institutional study, so it was reasonable to believe that there may be some differences in the results in this data. For this reason, other values for k were considered. To determine potential other values for k, a within-cluster sum-of-squares plot was used; a change in slope in the plot, or an "elbow," indicates the number of clusters that best describe the data (Fraley & Raftery, 1998).

Some items in the survey refer to "this course," and are considered course, or context, dependent. Since participants were from 14 different courses, only non-context dependent factors (Clarity, Alignment, and Future in Engineering) were used to cluster the students. A k-means cluster analysis was used, with random initial centers

for 100 random sets repeated over 500 iterations. This method ensures that the clusters which best describe the data are identified. The clusters were described by their mean scores for each of the three factors the data were clustered around and the two additional context-dependent factors (Effect of Future on Present and Endogenous Perceived Instrumentality). All five factor means were used to describe the clusters for additional information. The total variance in the dataset explained by the clustering was calculated using Equation 1.

Equation 1 Calculating the Total Variance Explained by the Clustering

$$\text{Total variance explained by the clustering} = \frac{\text{Total Within Sum of Squares}}{\text{Between Sum of Squares}}$$

A Silhouette plot was also used as an indicator that the data "belong" to the cluster the data is in. The silhouette of clustered data provides a useful visual tool when using k-means analysis. Silhouette measures the similarity of one participant to all other participants in that cluster using Euclidean distance; silhouette works best with spherical and compact clusters. When looking at a Silhouette plot, you want the silhouettes to be wide, and generally a silhouette width greater than 0.71 indicates a strong fit, while a silhouette width less than 0.25 indicates no substantial structure (Rousseeuw, 1987).

Once the clusters that best fit the data were identified, descriptive statistics (percentages) were used to identify the distribution of the clusters across all participants and across academic (year, major, university) and social identity

(gender, race, sexual identity) demographics. Any proportions that stood out were followed up with a chi-squared test for independence ($\chi_I{}^2$) to test that the demographic in question is independent, or not related, to the clusters (Rao & Scott, 1981). From a chi-squared test for independence, a *p*-value can be interpreted to determine if the demographic and clusters *are* statistically significantly related. For these tests and all tests in this doctoral study, significant *p*-values are considered and denoted as follows in Table 2.2. A *p*-value less than 0.05 would indicate that the proportions of the samples are significantly different with a 95% confidence level

Table 2.2 Significance Level and Notation for All P-Values. In this doctoral study, all significant p-values will be denoted with the following notation, following the p-value.

Significance Level	Confidence Level	Notation
$p<0.1$	90%	.
$p<0.05$	95%	*
$p<0.01$	99%	**
$p<0.001$	99.9%	***

If the chi-squared test was significant at the 95% confidence level or higher, the test was followed with a one-way multivariate analysis of variance (MANOVA) to determine which, if any, of the factor means are significantly different across these demographics. A MANOVA tests the hypothesis that two or more groups have the same mean on multiple variables (Aelst & Willems, 2011). In this case, the groups in question are the different demographic groups (i.e. first-year, sophomore, junior, senior), and the variables are the survey factors, Alignment, Clarity, and Future in Engineering.

2.6 Follow-Up quan Phase

The purpose of the Follow-Up quan Phase was primarily for participant selection. The results of the Exploratory QUAN Phase drove the need for gaining more insight into one of the clusters through an Explanatory Qualitative Phase. To identify students in this group, a second survey distribution was used in this Follow-Up quan Phase. In addition to identifying students with a certain way of thinking about their future careers, the longitudinal nature of the Follow-Up quan Phase addresses the research question, "How do engineering students' perceptions of their future possible careers change over one year for students in sophomore level engineering classes?"

Participant Selection

The target population of this phase is the same as the Exploratory QUAN Phase: students in large, sophomore level, CE, ME, and EE courses at large research institutions. Seventy-one students who completed the survey in the first distribution (Distribution 1) also completed the second distribution (Distribution 2); these students are the participants for this phase of the study.

Quality Considerations

The survey instrument used in this phase was tested for validity and reliability on this sample of students in the Exploratory QUAN Phase; since the number of participants (*n=71*) is too low for most validity and reliability tests, the sample for this phase was checked for representativeness of the Exploratory QUAN Phase participants.

Pearson's chi-squared goodness-of-fit test was used to determine how representative the distribution of demographics of the longitudinal sample was to the larger sample (Havlicek & Peterson, 1977). Welch's two-sample t-test for equal means was used to determine how representative the means of the two factor scores were. Showing that the sample is representative of the population on which this instrument was tested demonstrates the validity and reliability of the instrument for the sample is consistent with the testing done in the Exploratory QUAN Phase.

The chi-squared goodness-of-fit test determines whether there is a relationship between participating in the second distribution of the survey (*n=71*) and the demographic variable (Rao & Scott, 1981). The expected frequencies for the demographic variables were calculated from the independent sample from the first distribution (*n=677*). A chi-squared goodness-of-fit test was run to compare the distributions for four different demographics: year in school, university, race and ethnicity, and gender.

Because the four groups were determined based on the two factor scores, Clarity and Alignment, a Welch's two-sample t-test for equal means was used to determine if the means of Clarity and Alignment were unequal for the participants who did (*n=71*) and did not (*n=677*) complete the survey in the second distribution. A p-value higher than 0.05 would indicate that the means of the two samples are similar (Winter, 2013).

Data Collection

In Fall 2017, students who provided their email in the Distribution 1 (*n=746*), were sent an invitation to complete the survey a second time (see Figure 2.2). The survey consisted of the same items provided in the Exploratory QUAN Phase. The participants were given one week to complete the survey, were sent two reminder emails, and were offered a chance to win a $20 gift card.

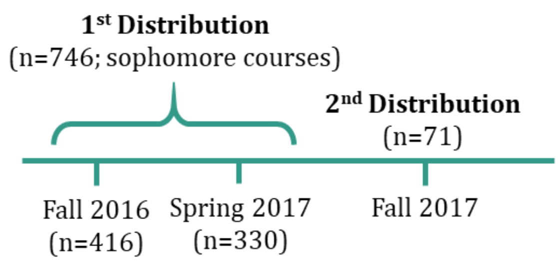

Figure 2.2 Longitudinal Data Collection Timeline. Participants in the Follow-Up quan Phase took the survey either in the 2016-2017 academic year (Distribution 1) and again in the 2017-2018 academic year (Distribution 2).

Data Analysis

The 71 participants were each placed in appropriate clusters for the first and second completion of the survey. The cluster placement from the first distribution was determined based on the cluster analysis performed in the Exploratory QUAN Phase. The participants were placed in a cluster or group in Distribution 2 based on the descriptive statistics of the clusters in the first distribution. For example, if a participant's survey scores in the second distribution match the means for a cluster identified in Distribution 1, the participant was placed in that cluster for Distribution 2. A second cluster analysis would not be appropriate given the small *n* and because

the objective of the phase is to identify students who fit in the group identified in the Exploratory QUAN Phase, not to identify the clusters that best fit the data.

The cluster or group for Distribution 2 was determined using cutoff values for two of the factors: Clarity and Alignment of Future Possible Careers. A "cutoff" value was identified for each of the factors based on the means of the factors—Clarity (μ_{CL}) and Alignment (μ_{AL}) of Future Possible Careers—of Distribution 1. "

Next the shift in the different ways of the thinking about the future was measured using a count of students who moved from one cluster to another (i.e. the number of students who were in cluster 1 in Distribution 1 and in cluster 2 in Distribution 2). The proportion of participants shifting to a cluster in Distribution 2 ($Cluster_2$) given being in a cluster in Distribution 1 ($Cluster_1$) was determined using Equation 2.

Equation 2 The Probability of Shifting to a specific cluster in Distribution 2 ($Cluster_2$) *given being in a specific cluster in Distribution 1* ($Cluster_1$)*.*

$$P(Cluster_2|Cluster_1) = \frac{The\ total\ number\ of\ participants\ shifting\ to\ Cluster_2\ given\ Cluster_1}{The\ total\ number\ of\ participants\ shifting\ from\ Cluster_1}$$

2.7 Explanatory QUAL Phase

In the Explanatory QUAL Phase, we address the research question, "How do students who quantitatively describe lower clarity of future possible careers and conflicting ideal and realistic future possible careers think about their future careers; how are these students experiencing pursuing their engineering degree; and what decisions are these students making with respect to their courses?" The need for this phase

arose from the need to describe new findings in the Exploratory QUAN Phase in the same depth as the Exploratory QUAL Phase. This phase is primarily directed content analysis to describe the group of students who quantitatively scored similarly in Distribution 2 of the survey.

Participant Selection

The target sample for this phase are all the students who were identified in the Follow-Up quan Phase as having quantitatively lower clarity of future careers and conflicting ideal and realistic future possible careers. Of these *n=31* students, *n=9* students were interviewed. A description of the participants' pseudonyms, majors, and year in school is shown in Appendix C. The participants consisted of primarily junior students, two sophomores, and one senior. The one participant who was a senior was removed from data analysis, due to not fitting the target population for the mixed methods study. A detailed description of participants is in Chapter 7, pg. 118.

Data Collection

One to two weeks after students completed the survey in the Follow-Up quan Phase, I identified students who fit into the target population of low clarity of future careers and conflicting ideal and realistic future possible careers, as described in the Follow-Up quan Phase. I emailed each of these students and asked if they would like to participate in follow-up interviews. I sent two reminder emails and offered them a $20 gift card for a 2-hour interview.

Nine of these participants volunteered to participate and were interviewed. We interviewed these nine participants using a similar semi-structured interview protocol as the Exploratory QUAL Phase, with prompts added to the end of the protocol on background and survey validation (Appendix M). I was the lead interviewer for each of the interviews, and in eight of the interviews, a second interviewer sat in on the interviews to ensure consistency in the questions asked, and to ask clarifying questions when necessary. Seven of the interviews occurred one week after the end of the survey distribution, and two of the interviews occurred two weeks later. Interviews ranged from 45 minutes to 90 minutes in length.

Prior to the interview, I pulled their survey responses to compile follow-up questions in the interview. I used their survey responses to inform the additional prompts for survey validation at the end of the interview; my experience with the protocol from the Exploratory QUAL Phase, helped me be consistent with my prompts across all interviews in this doctoral study, and reduce any bias I may have had from my knowledge of the quantitative scores. I also memoed before and after the interviews for each participant to help prepare me for the interview and acknowledge any bias or initial impressions with the participants prior to data analysis. Example memos are included in Appendix G. Each of the interviews were audio recorded; I listened to the interview audio to make sure everything recoded, then submitted the recordings for transcription.

Data Analysis

Directed content analysis was used to code all the interviews following the codebook created in the Exploratory QUAL Phase. Directed content analysis uses a pre-defined set of codes/code definitions to drive analysis and allows for codes to emerge from the data. Directed content analysis is appropriate for this study because it allows for parallel descriptions to the previous findings, in the Exploratory QUAL Phase, while allowing for an authentic description of how this group experiences a phenomenon, which fits with the philosophy of phenomenography and can add to the phenomenographic findings in the Exploratory QUAL Phase. The predefined set of codes are the codes from the final codebook resulting from the Exploratory QUAL Phase. This detailed codebook, provided in Appendix E, is considered a result of the Exploratory QUAL Phase, and as such will be explained in depth in Chapter 7 (pg. 119).

An external transcription service transcribed the audio recordings from the interviews. I read through the transcripts while listening to the audio twice for each participant. The first round allowed me to check for inconsistencies in the transcriptions and format the transcripts appropriately. During the second listen, I focused on being immersed in the data, so that I could understand each participant's tone throughout the interview and be able to read the transcript without listening to the audio while still being able to recall what the participant sounded like at that point. After listening the second time, I read through each participants' transcript and

memoed my initial interpretations of what the participant was describing. I used extended phrases and paragraphs and wrote my interpretation beside that section to continue my immersion into the data.

Then, using a qualitative coding software, RQDA, (Appendix F) and the codebook from the Exploratory QUAL Phase, I started coding the interviews one at a time, with coding segments of about one sentence. I identified if the meanings in that coding segment fit with any identified codes; if the coding segment seemed significant to the research question but did not fit with any existing codes, I marked it with an initial "?" code. Towards the end of the first cycle, I started noticing patterns in the "?" codes; at the end of the first cycle of coding, I looked at the "?" codes, grouped them in similar meanings, named the code, and added an entry to the codebook with a description and example for consistent coding in the future. I continued with a second round of coding to consistently code each of the interview using the original codebook with the additional codes. At the end of this round of coding, I read through each coded transcript and created a summary sheet for each participant. On this sheet I drew out themes, such as extension in time, connections the students described and added a couple of sentences describing the illustration.

I then talked through the summary sheets with the research team, and we began to identify significant themes. These conversations also held me accountable for consistent coding and offered alternative and fresh perspectives of interpretation.

Quality Considerations

Having a second interviewer during the interviews for this phase helped me balance the need for remaining consistent in the interview protocol and interpreting the interview to ask meaningful survey validation questions at the end. Practice with this interview protocol also helped ensure this consistency which is important in phenomenography to make sure I am capturing the phenomenon of interest consistently for all participants.

Because this data collection occurred sequentially after the Exploratory QUAL and Exploratory QUAN Phases analysis, I had some predetermined ideas or assumptions about what to expect from these interviews. I had to be careful in terms of communicative validation to truly allow the participants to construct or express their social realities or experiences without inserting my own assumptions. The memos before and after interviews allowed me to reflect on, be aware of, and minimize these assumptions during the interview processes.

There was a similar concern when analyzing the data that I was inserting my own biases in the interpretation. Having an existing, well-defined codebook allowed me to be consistent across interview analysis in the Exploratory QUAL and Explanatory QUAL Phases. Allowing for emergent codes and interpreting those codes after reading through all the interviews also fit with the ontological assumptions of the doctoral study: that there exists a finite number of ways of thinking about the future that are similar and that vary in different aspects. I believe the method of coding, directed

content analysis, aided in the procedural validation, or the fit between the reality and the theory generated. Discussing the new codes as they emerged with the research team also helped keep my biases in check and keep my coding consistent. After the initial protocol development, I also did not connect the study IDs for the interview participants to their quantitative results until *after* the qualitative analysis was complete and I was ready to mix the data.

2.8 Levels of Mixing

The guiding research question of this study, "In what ways are mid-year engineering students at large research institutions thinking about their future careers and how are those perceptions related to their current academic actions and decisions?" drove the need for mixed methods. The types of mixing here are defined as the level of interaction between the quantitative and qualitative phases of the study (Bryman, 2006; Cresswell & Clark, 2011a; Greene et al., 1989; Moran-Ellis, 2006; Onwuegbuzie & Johnson, 2006). The target population of this study (mid-year engineering students at large research institutions) is too broad for most traditional qualitative methods, including the methodology of phenomenography, which the wording of the research question seems to imply ("In what ways…"). To capture the experience of the phenomenon (thinking about their future careers) for mid-year engineering students in large research institutions, a combination of qualitative methods (i.e. phenomenography), quantitative methods (i.e. cluster analysis), and mixing (i.e. survey development) are needed.

Development

Development mixing, or the results of one phase being used to inform the design, sampling, and/or implementation of another phase (Greene et al., 1989), is the most prominent form of mixing in this multi-phase mixed methods study. Development mixing drove the design of the study, particularly in the addition of the Follow-Up quan Phase, the Explanatory QUAL Phase, and the Survey Development Phase. The resulting groups and the themes and code categories that describe these groups in the Exploratory QUAL Phase were used to refine a survey instrument intended to capture these groups quantitatively in the Survey Development Phase.

Development mixing was used to determine the research purpose and research questions of the Follow-up quan Phase and Explanatory QUAL Phase, design the methodology of these phases, and sampling for the Explanatory QUAL Phase. The results of the Exploratory QUAN Phase indicated new findings—a new group not identified in the Exploratory QUAL Phase. The new findings drove the need for qualitative data to 1) determine if the new group is qualitatively different from the groups identified in the Exploratory QUAL Phase and 2) describe the new group in the same depth as the groups identified in the Exploratory QUAL Phase.

To meet the above research objectives, the need of a replication methodology of the phenomenographic approach, using directed content analysis, in the Explanatory QUAL Phase was determined. The need to characterize students who are quantitatively placed in this new group at the time of the interviews drove the design

of the Follow-Up quan Phase; this phase "binned" students into clusters to quantitatively place students in the new group to be invited to participate in the Explanatory QUAL Phase.

Complementarity

The description of this new group is the result of complementarity mixing, the enhancement and clarification of the results in the quantitative phases with qualitative methods (Greene et al., 1989). The Exploratory QUAN and the Follow-Up quan Phases provided a quantitative description of students in this new group, which helped the researchers identify that this group was indeed distinct from the previously identified groups. The Explanatory QUAL Phase enhances and clarifies the quantitative findings with more in-depth descriptions of the constructs of interest. Each method capitalizes on the strengths of that method to result in the description of how the new group perceives their future careers and how those perceptions relate to their academic actions and decisions.

Triangulation

The process of survey development, in the Survey Development Phase, requires triangulation mixing of quantitative and qualitative data. Triangulation mixing, or the corroboration of qualitative and quantitative methods (Greene et al., 1989), is explicitly used in the external validation of the survey development. The resulting quantitative clusters were compared to the qualitative categorization of three participants to determine the effectiveness of the survey.

The survey development process continues throughout the doctoral work, where the Explanatory QUAL Phase provides clarification of how the survey was interpreted in the Follow-Up quan Phase.

Expansion

Although several of different types of mixing are used in this study, the typology of this study is expansion design, where the different phases address different research questions (Creamer, 2018) and together answer the guiding research question for the doctoral study. Expansion mixing is used to extend the breadth of both the quantitative and qualitative methods (Greene et al., 1989). Expansion is arguably the most crucial mixing in this study, as it is used to pull together the results of all of the phases to answer the guiding research question. Expansion mixing allows for the scope of this study to extend beyond that of one methodology and is the primary reason for the selection of mixed methods in the design of this study. In Chapter 8, the results of the phases are holistically evaluated, providing an interpretation of the results of individual studies considered in the doctoral study as a whole.

2.9 Positionality Statement

As I transition now into the results of this study, I want to unpack my own experiences related to the nature of engineering students and the phenomenon of thinking about the future, which may provide context to my interpretation of the data. I received my

Bachelor of Science in Electrical Engineering (EE) at a large, research-intensive institution. I experienced the perception of prestige and superiority that comes with being in an engineering major from my peers, mentors, and even strangers. There was an expectation that the coursework will be and should be difficult, which is the primary source of the perception of prestige that comes with being an EE major. I chose EE because of my love of math and because I believed I could do math, help people, and get a job with an engineering degree, as opposed to other STEM (Science, Technology, Engineering, and Mathematics) disciplines.

I had multiple career plans that often changed or existed all at once; I had first wanted to be a teacher, then wanted to use my engineering degree to help improve education. At some points I considered Nuclear Engineering. There were times I struggled with the career path I wanted and the career path that was "correct" or the right way to go about things. I experienced a trauma as an undergraduate that changed my priorities to focus more on the present and my well-being in the present, which eventually empowered me to pursue the path that was not necessarily the "right way" but was the right path for me.

CHAPTER 3

EXPLORATORY QUAL PHASE

Identifying Different Ways of Thinking About Future Possible Careers: A Phenomenographic Approach

3.1 Purpose

In this first phase, we seek to answer the research question: "What are the different ways mid-year engineering students are perceiving their future career goals and how those perceptions interact with their actions in their present engineering coursework?", by borrowing from aspects of phenomenography. In this phase, we focus on understanding students' perceptions of their future career goals and how those goals do or do not relate to their present actions. The phenomenon the students are experiencing is thinking about their future possible careers; the context in which

the students are experiencing the phenomenon is in their current engineering coursework and the attainment of their engineering degree.

After the data collection of semi-structured interviews focused on future goals and their connections to the present with sophomore and junior biomedical (BME) and mechanical (ME) engineering students (*n=18*) and phenomenographic analysis of the interview transcripts, a description of participants, identification of codes, themes, and an outcome space with three ways of experiencing the phenomenon—thinking about future possible careers—were identified.

3.2 Results

Three different ways of thinking about the future were identified and described using constructs from the future time perspective and future possible selves theories, such as clarity of the future and the alignment of ideal and realistic future possible selves, and through an analogy with different shapes of ice cream cones. The three different ways of thinking about the future are denoted as Clear and Aligned (Sugar Cone), Unclear and Aligned (Cake Cone), and Clear and Unaligned (Waffle Cone).

Participant Description

The participants consisted of primarily sophomore students interviewed at the end of their second year; the four students who were juniors were interviewed at the beginning of their third year. Nine of the participants were BME majors and eight participants were ME majors. One student, Katerina, was a BME major at the time she

was recruited but switched to Materials Science and Engineering (MSE). She is included in the analysis because at the time of her interviews, she had experienced the phenomenon in the same context as the other BME and ME participants.

Sixteen of the eighteen students were Caucasian, one student identified as African American, and one student identified as being of African descent. Additionally, two students were of international origin. Seven of the eighteen students identified as female and eleven identified as male. Racial and ethnic status is not attached to specific students to protect the anonymity of participants. Although students who identify as Caucasian make up a majority of undergraduate engineering students nationwide (Yoder, 2012), sixteen out of eighteen Caucasian students is over representative of the national average. However, the racial and ethnic demographics are fairly representative for the university at which this study was conducted, and gender demographics are fairly representative for the respective disciplines, with women being overrepresented for ME (37.5% as opposed to 12.4% national average) (Yoder, 2016). All names used for participants are pseudonyms. In Table 3.1 is a description of the participants including names (pseudonyms), background (major, year in school, semester of interview), and a brief description of their perceptions of the future.

Table 3.1 Description of Participants in Exploratory QUAL Phase

Name	Major	Year	Interviewed	Perceptions of the Future (Cone Type)
Caroline	ME	Sophomore	Spring 2014	Unclear and Aligned (Cake) • Ill-defined characteristics • List of possible ME careers
Damon	ME	Sophomore	Spring 2014	Unclear and Aligned (Cake) • Likes having options as an ME • Does not want to go to law school or medical school
Katerina	BME	Sophomore	Spring 2014	Clear and Aligned (Sugar) • Wants to work in national lab for cell targeting for curing cancer • Wants to gain knowledge and help people
Katherine	BME	Sophomore	Spring 2014	Clear and Aligned (Sugar) • Looking for internships to help her become a radiologist • Pursuing master's degree, followed by medical school, working as a radiologist, and with Doctors Without Borders
Stefan	ME	Sophomore	Spring 2014	Clear and Unaligned (Waffle) • Wants a career in aviation • Believes he'll work at an automotive company
Bonnie	BME	Junior	Fall 2014	Clear and Aligned (Sugar) • Ideal and realistic future possible career of being a doctor • Wants to help people
Jeremy	BME	Junior	Fall 2014	Clear and Aligned (Sugar) • Pursuing a career in research and development in orthopedics • Wants to make money and help people
Matt	BME	Junior	Fall 2014	Clear and Aligned (Sugar) • Wants to help people by creating biological implants • Focused on gaining knowledge on bone and material properties
Silas	BME	Junior	Fall 2014	Clear and Aligned (Sugar) • Wants to work in the medical field and help people • Exploring options in BME and gaining skills to reach his goal
Chris	ME	Sophomore	Spring 2015	Clear and Aligned (Sugar) • Wants to design sustainable transportation • Has contingency plans to reach his outcome goal of making money

Name	Major	Year	Interviewed	Perceptions of the Future (Cone Type)
David	BME	Sophomore	Spring 2015	Clear and Aligned (Sugar) • Working towards being a project manager integrating nerve cells to create prosthetics
Emily	ME	Sophomore	Spring 2015	Clear and Aligned (Sugar) • Has two possible career paths: industry or graduate school • Has well-defined future goal of working in BME research and development for implants at an orthopedic company
Logan	BME	Sophomore	Spring 2015	Clear and Aligned (Sugar) • Ideal and realistic future working as a research scientist • Not sure of the best path to that future • Focusing on BME classes, which he believes will be more useful
Will	BME	Sophomore	Spring 2015	Clear and Aligned (Sugar) • Wants to go to medical school, study cardiothoracic surgery, and own his own practice • He does not want to be a family doctor because it isn't high pressure enough
Jacob	ME	Sophomore	Spring 2015	Clear and Unaligned (Waffle) • Has well-defined ideal first job after graduation of working at an aerospace company • He believes he will be able to achieve his less defined realistic (and avoided) future
Anna	BME	Sophomore	Spring 2015	Unclear and Aligned (Cake) • Keeping options open until she decides which of her options as a BME will make her the happiest • Gaining broad knowledge to prepare her for her future
Mary	ME	Sophomore	Spring 2015	Unclear and Aligned (Cake) • Enjoys ME for its flexibility • Trying internships in different areas to help her decide her ideal/realistic future possible career
Noah	ME	Sophomore	Spring 2015	Unclear and Aligned (Cake) • Wants a career that is challenging and has variety • Will follow the path he feels called to follow • Believes his entire college experience is useful for his future

Code Book and Themes

The defining of a code book is one of the major findings of this phase that is crucial to future phases, namely the Explanatory QUAL Phase. This code book (condensed in Table 3.2, full in Appendix E) shows code names, definitions and example quotes. These codes are divided into three coding categories to distinguish between the three different groups: Description of Future Careers and Career Goals, Attitude Towards Future Possible Careers, and Relationship between the Future and Present.

Table 3.2 Condensed Exploratory QUAL Phase Codebook. The code's name, description, or definition, an example, and the construct in which it fits in is shown.

Code	Description	Example
Clarity of Future Careers and Career Goals		
Well-Defined Future	The student has a defined future goal that they want to attain. The goal should be clearly defined by the student.	"I think I would be a radiologist and I would be, um, but also still working to develop the technology and make it more accessible and portable and things like that and then, um, hopefully work with Doctors Without Borders."
Ill-Defined Future	The student describes a future goal using ambiguous terms. The goal is not clearly defined by the student.	"I don't know [what my goals for the future are], just solving problems that have never been solved before really excites me."
Outcomes of Future Career	The student describes the outcomes of their future career	"I like to help people, see people feel better and succeed. So that would be my ultimate goal is to help people."
Alignment of Future Possible Careers		

Ideal Future	The student describes what they ideally want to do in the future.	"Honestly, my ideal future would be being able to travel without restraint and not having to worry about working."
Realistic Future	The student describes what they can realistically do in the future.	"Probably realistically, if I didn't get up to being a pilot, then working at a company like [major aerospace company]"
Undesired (Avoided) Future	The student describes what they do not want to be in the future	"An automotive engineer. I don't want to go into automotive. It just doesn't interest me. "
Relationship Between the Future and Present		
Contingent Goal Paths	The student describes a series of steps or paths needed to reach a distant future goal.	"I'd like to go to med school and study cardiothoracic surgery, eventually, so... bioengineer branching into med school after I graduate hopefully."
Perceived Instrumentality	The student describes how relevant they view certain tasks.	"Probably my [BME] classes [are] the most [relevant to my future]. I mean the general engineering kind of lays the groundwork for getting you ready course-wise. But I think the actual [BME] courses are the most applicable, to what we would be doing in a [BME] field."
Perceived Effect of the Future on the Present	The student describes how the future impacts what they do in the present.	"Medical school is what drives me to try to make as high [grades] as possible because I know how competitive it is to get in"

Outcome Space

The outcome space of this study captures the interplay between the participants' perceptions of their future careers and their behavior in the present. The outcome space that contains the themes described in the codebook is represented on three axes, Extension (how far into the future students are perceiving their future careers), Alignment of Future Possible Careers (how similar the students' ideal and realistic future possible careers are), and Perceived Instrumentality (how useful they perceive their engineering coursework to be for their future), as shown in Figure 3.1. We

conceptualized Future Time Perspective as being a cone-shaped space within this axis system (Figure 3.2). The position of the base of the cone was determined by the extent to which the students' ideal future possible career was also attainable. The length of the cone was determined by how far into the future students are perceiving their future. The narrower the cone, the more defined, or clear, the participants' descriptions of the future and the more participants believe their engineering coursework will be useful for their future.

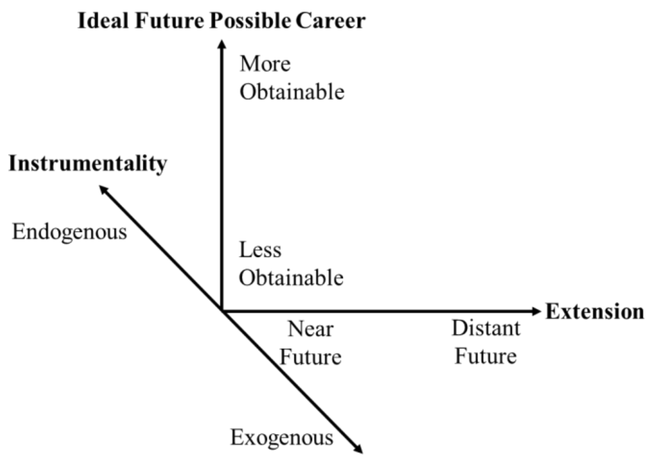

Figure 3.1 The Structural Framework of the Outcome Space. Represents the participants' descriptions of their perceived future possible careers and the connections between those perceptions on their present choices and behavior, includes three axes: the extension of the students' future orientation (extension), how obtainable they perceived their ideal future possible career (ideal future possible career), and how useful the student found present tasks to be for their future (instrumentality).

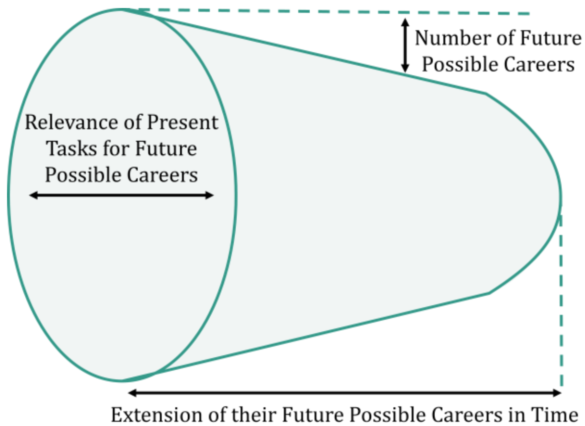

Figure 3.2 Perceptions of Future Possible Careers as Cones. Students' perceptions of their future possible careers in the context of their current engineering coursework are represented as a cone shape within the structural framework of the FTP axis system.

Three Different Ways of Thinking About the Future

Participants demonstrated three distinct ways of perceiving their future careers in the context of their present engineering coursework, represented as cones in the outcome space. The shapes of the cones are analogous to the shapes of ice cream cones (sugar, cake, and waffle). The groups are named after ice cream cones so that the group names will be visually impactful. The three groups will first be described individually, then all three groups will be compared and described in terms of the outcome space.

The Sugar Cone: Clear and Aligned

Participants with a Sugar Cone way of thinking described one well-defined future possible career (clear) that is attainable and ideal (aligned). That one well-defined

future career helps students determined which tasks are most important. The participants described prioritizing tasks that will help them reach that one well-defined future career. The visual representation of Sugar Cone is shown in Figure 3.3.

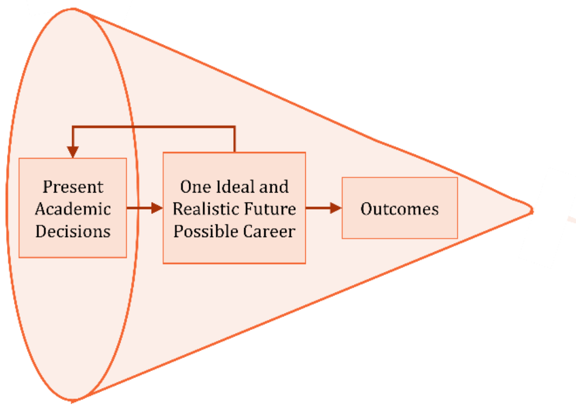

Figure 3.3 Sugar Cone participants' clarity and extension in their descriptions of their future possible careers is represented in a narrow and long cone. Sugar Cone students believe they can attain their ideal future career and have established a narrow range of perceived instrumentality of present tasks based on their ideal future possible career.

A well-defined future career is a defining characteristic of the Sugar Cone group. Participants in this group defined their futures with a high level of clarity deep into the future. Sugar Cone participants were able to describe their future careers well beyond graduation, and in many cases, up until retirement. When prompted, Emily (Sugar Cone) described in detail her future self in ten years:

> I really see myself in the [BME] field doing R&D for a company, orthopedics, possibly implants, whatever they have to offer, and I could get excited about. (Emily, Sugar Cone)

Another distinguishing factor of the Sugar Cone group is the matching ideal and realistic future possible career. Participants in the Sugar Cone group describe an ideal career that is also attainable. Throughout the course of Katherine's (Sugar Cone) interview, she establishes that both her ideal and attainable careers are that of a radiologist working with Doctors Without Borders. Participants in Sugar Cone also described outcomes of their distal future goals such as being successful (Logan, Sugar Cone) or helping others (Will, Sugar Cone).

The Waffle Cone: Clear and Unaligned

As shown in Figure 3.4, participants in the Waffle Cone group describe two well-defined future possible careers (clear)—one ideal and unattainable and the other attainable and avoided (unaligned)—as well as the breadth of present tasks that may be useful to one or both of their future possible careers.

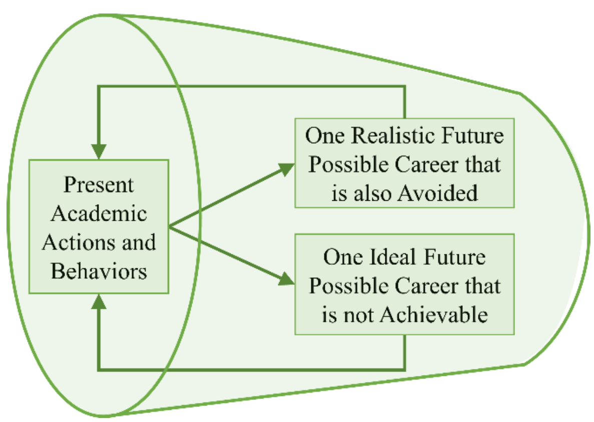

Figure 3.4 Waffle Cone students describe the future up to their first job after graduation, which is represented by a truncated cone. These students do not believe their ideal future possible career is attainable but have narrowed down tasks with perceived instrumentality based on both their ideal and attainable possible careers.

Participants who described a Waffle Cone way of thinking were characterized by future careers that are well-defined, but with no expressed future goals beyond ten years, and no expressed desired outcomes of their future careers. When discussing ideal, realistic, and avoided future possible careers, participants in Waffle Cone descriptions indicated a mismatch between their ideal and realistic future possible careers. Stefan (Waffle Cone) described his ideal career to be with [major aerospace company], but believed he could attain a position at [major automotive firm], which matches his later description of his avoided future possible career:

> [I don't want to be] in a place that's really corporate like [major automotive firm]. Like, you can move up and it's a great job obviously right out of college, but I can only move up so much. And so that's one thing that I don't want to do forever and just being in a really corporate business. (Stefan, Waffle Cone)

The Cake Cone: Unclear and Aligned

Participants in the Cake Cone group described a broad perception of the future, where the present is driving perceptions of the future and not the other way around. These traits are represented visually in Figure 3.5. When describing their future possible careers, participants in the Cake Cone group used uncertain or ambiguous descriptions, and did not describe goals beyond graduation:

Um, I don't really know [what I'm actively striving for]. I'm just you know, sort of living life day-by-day just trying to get through college at least." (Damon, Cake Cone)

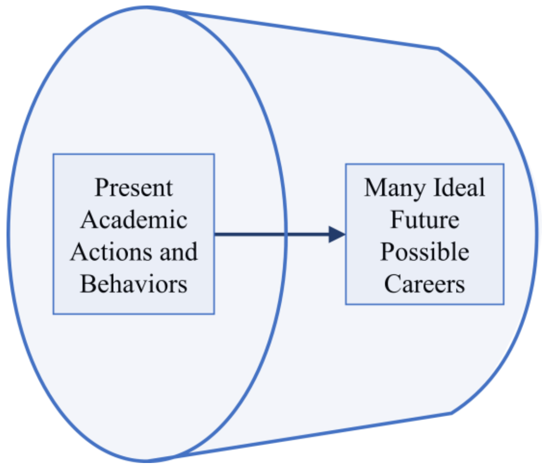

Figure 3.5 Cake Cone students describe their future careers in ambiguous terms, and often do not have a defined future possible career, even for their first job after graduation. This breadth in their descriptions of and short extension of is represented in a broad and truncated cone. Cake cone students believe that they will be able to achieve their ideal future career once they define it, and they are using their present academic experiences to begin to define their future possible careers.

Because of their broad perceptions of the future, participants in Cake Cone found most tasks to be useful for their future. When asked what parts of her education she sees as relevant, Caroline (Cake Cone), responded, "All of it."

3.3 Discussion

Now that I have introduced the three different ways of thinking about the future, I will discuss in more depth the distinguishing characteristics of the three different groups in terms of the outcome space.

Clarity of Future Career Goals

Participants varied in how far into the future they described, and the definition with which they described, their future possible careers and career goals. Sugar Cone participants described their future possible careers in much more depth than participants in other groups:

> I'd like to work on creating more organic implants for like, like bend breaks and such, um, I don't really know the title or what, how you'd classify that but, um, right now if I could choose I really want to do work in that field where, because right now you put metals and all sorts of stuff in people's bodies, but after 20 years they break down, it doesn't work, you've got to go back in and that's all sorts of trauma to the tissue and just, I feel like there's a better way for that. (Matt, Sugar Cone)

Participants in Waffle Cone described their future possible careers with some detail, but with a focus on their first job after graduation and their employers:

> I'd really like to work for [major aerospace company]. Especially because I live in [nearby city] right now, and they have a plant, factory, whatever. They're expanding like crazy, so they've got all sorts of stuff down there. I'd love to work there and help them build airplanes and stuff. (Jacob, Waffle Cone)

Participants with a Cake Cone way of thinking defined their future in terms of careers they did not want to do and desired characteristics of future careers, as described in the following section. When asked, "What are your goals for the future?" Cake Cone students often responded with uncertainty, with statements like "I'm not sure…" or "I don't know…" Noah responds to "What are your career goals for the future?":

> I don't really have a set career goal. I definitely want to move up, but I don't want to be in a position to where there's not a separation between work and life. I'm open to working overtime and different things like that but I don't want it to be where I'm constantly having calls and things like that while I'm at home. I'd like to move up and I'd like to be successful in my career but money's not the most important thing. I think engineers make good salaries but if I wanted a bunch of money I would've become a doctor or something like that. (Noah, Cake Cone)

Unlike the Cake and Waffle Cone groups, participants in the Sugar Cone group would describe their future beyond their first job after graduation, often up until retirement, and included descriptions of outcomes from their future possible career:

> [My ideal medical practice would be] a really family friendly environment, just serving other people. That's what I really want to do. And I like to help people, see people feel better and succeed. So that would be my ultimate goal is to help people. (Will, Sugar Cone)

> I just want to help cure people. But I feel like if I come up with a cure, let's say for a new drug delivery method, that will cure so many more people than I could being a doctor. Like let's say you saved three lives a week, even if you're really lucky, but if you find a way to deliver [therapeutic] drugs you can save thousands of people a day if you were lucky enough. (Katerina, Sugar Cone)

Alignment of Future Possible Careers

Another key theme distinguishing these three groups is how they differentiated between their ideal, realistic, and avoided future careers. Participants in Sugar and Cake Cone perceive their ideal future possible careers as being obtainable, for example, David (Sugar Cone) described his ideal future career as "a project manager working on the innovation of prosthetic limbs, like being able to fully integrate them

with nerve cells, and making them lighter," which he believed was obtainable because "there is always more to do, more ways to improve medicine and prosthetic limbs.

However, Participants in the Waffle Cone group have conflicting ideal and realistic future possible careers:

> [Ideally, I see myself] like, working in a factory, [but realistically] I'm not expecting that to happen. (Jacob, Waffle Cone)

Waffle Cone students indicated that they may possibly be able to achieve their ideal future possible career in the distant future; however, their perceptions of the future did not extend beyond the first job after college. When asked about 10 years in the future, Stefan (Waffle Cone) responded with ambiguity:

> Um, I, right now if you asked me what would probably happen I would probably end up taking the position at [major automotive firm] …. I guess I can't really speak for what I'll feel like in 10 years. (Stefan, Waffle Cone)

While participants in the Waffle Cone group described their realistic future possible careers as also being their avoided future possible careers, participants in Sugar Cone described their avoided future possible careers in similar detail and in a similar field to their ideal and realistic future possible career and participants in Cake Cone describe an avoided career in unrelated fields. For example, Will (Sugar Cone) describes his ideal and realistic future possible career as being a cardiothoracic

surgeon with his own practice, while his avoided future possible career is to be in general practice. Silas (Sugar Cone) echoes this theme, while Damon (Cake Cone) describes an avoided career unrelated broadly to his ME degree:

> Ideally, I think the anesthesiologist assistant or any sort of person in, you know, a hospital setting would be a goal. I've never really wanted to be like a surgeon or a doctor. (Silas, Sugar Cone)

> I don't want to be a garbage man or sort of a standard factory worker. I don't want to necessarily just work at a desk all day. I definitely don't want to be an electrical engineer after this last class [electrical engineering for non-majors]. (Damon, Cake Cone)

Unlike participants in Sugar and Waffle Cones, when commenting on the specific jobs participants in Cake Cone wished to avoid, they turn their response to define desired characteristics of their future careers:

> I wouldn't want to be stuck doing just one tiny part. I'm a big picture person so it would be really fun to be involved in all aspects of something. (Caroline, Cake Cone)

Relationship Between Future and Present

As the participants' perceptions of the future have narrowed, so have their perceptions of instrumentality, or what will be useful for their future. Participants in

the Sugar Cone group describe specific coursework or skills that will or will not be useful for their future, and how they prioritize that coursework.

> I'm definitely going to be inventing things. I need to have their weights balanced out properly. I'll have to have enough force going into whatever pieces I need. With Statics and Dynamics, of course, that's all it is. With that, I'll be able to properly configure my machines, my inventions so that they work as I want them to, and without Statics and Dynamics, I would not be able to even come close to that. (Chris, Sugar Cone)

> I think working in groups [is relevant to my ideal self], that would be a good example of one. Because it's not my preferred thing to do, and I always find that I like different ways of thinking about things than other people, but basically every class forces you to do at least one group project throughout the semester. And I realize that both as an engineer and as someone in the medical field, you're going to have to work in groups on projects and with people. (Bonnie, Sugar Cone)

Similar to the participants in the Sugar Cone group, participants in the Waffle Cone group focused on describing skills that could be useful in their ideal or attainable careers, only with more breadth than Sugar Cone:

> Definitely classes like Statics and Dynamics [are relevant to my future] … and those kinds of classes. Those definitely have a lot of real-world applications to it. Other math classes like [Ordinary Differential Equations] and stuff, not so much. But any level courses, like ... [Mechanical Engineering Laboratory 1] those definitely seemed like they had a lot of relevance to a real-world job. (Jacob, Waffle Cone)

Participants in the Cake Cone group did not describe their future as influencing their present behaviors; however, these participants did describe a broad perception of instrumentality to fit their broad definitions of their future possible selves. Noah described how any course will be useful for his future by comparing his professors to his superior in his undefined future possible career:

> I think pretty much all of it [my education] is [relevant] because even when going down to the level of dealing with a professor, it relates to dealing with a boss. You can have a good professor or bad professor; a good boss or a bad boss. You have one that has reasonable requirements or one that has unreasonable requirements. I've had both and so that teaches you that. Learning the technical skills that we'll be using in the actual job to solve real-life problems. (Noah, Cake Cone)

Participants in Cake Cone described their future as influencing their present decision in only a broad sense, where the focus remains on the present. For example, participants in Cake Cone focused on opportunities in the present that will provide them with a breadth of opportunities in the future.

> I'm not trying to force a future for myself at this point. More so, be out there looking and embrace what opportunities are given to me. I used to be dead set on like what I wanted to do but I realize that's not necessarily going to make me happy where I want to be. (Mary, Cake Cone).

Unlike Cake Cone, participants in Waffle and Sugar Cone groups described a feedback loop between the present and the future, where the future informs the present and the present informs the future. Participants in the Sugar Cone group created contingent goal paths that connect their present to the future. Anna (Sugar Cone) described her first job after graduation as being hands on and eventually working up to a management position, because "that is the logical progression." When describing their future goals, along with the detailed descriptions of their future possible careers, participants in Sugar Cone described contingent goal paths that lead to those possible selves:

> I'm going to stick with the undergraduate [BME] program, pursue a Master's, and then my goal is to ultimately work for a medical device

> company in research and design. So, yeah, that'll be the ultimate goal. Probably a Ph.D. after I start working, too. (Jeremy, Sugar Cone)

Participants in Waffle Cone did not express contingent goal paths to reaching a distant future goal, but they did describe how their future goals are influencing their current actions, such as applying to many internships to improve their career prospects.

> I'm just applying for every internship that comes my way. Mostly [for] money, really. But also work experience that I can use, so when I do start applying for jobs more people will give me offers and I'll be able to have more options to pick something that I actually like, instead of settling for whatever I get. (Jacob, Waffle Cone)

Participants in Waffle Cone described multiple future distal goals and work towards making those goals more achievable. Differing from participants in Waffle Cone, participants in Sugar Cone may have multiple contingent paths to reach the *same* distant future goal. Emily described two paths she can take to work reach her ideal future possible career in research and development in BME:

> I'm trying to figure out two paths that I want to go, possibly. I'm an ME, so I could possibly just do summer internships and go straight into the industry when I'm done with my undergrad and hopefully get a master's through the company that I join, or I could go the other route. I'm doing [BME] research, and I really enjoy it, so I may choose

> to go straight into my PhD in [BME], in which case, I'll need to look
> for a graduate program after school. (Emily, Sugar Cone)

In both of Emily's contingent goal paths, she described a series of goals that are dependent on each other to achieve her ideal future possible career. She described actively striving towards both paths and described both paths with some level of clarity.

3.4 Implications and Next Steps

In this initial phase, we have identified three different ways of thinking about the future, each with distinct characteristics related to their future time perspectives and future possible selves. These different ways of thinking are distinguishable through their key characteristics, particularly clarity of the future, alignment of their future possible careers, and the relationship between the future and the present. These different ways of thinking give some insight into how students in ME and BME are thinking about the future and how it might be influencing their behaviors in the classroom. Detailed implications for these three ways of thinking of the future in relation to the total dissertation are included in Chapter 8 (pg. 143) and Chapter 9 (pg. 171).

Developmental Mixing

Now that we have identified key characteristics in this sample of participants distinguishing different ways of thinking, the next steps to answer the guiding

research questions is to develop an instrument to quantitatively measure different ways of thinking about the future. Developing an instrument will allow me to gain an understanding of how mid-year engineering students are thinking about their future for a broader population of students. The development of this instrument is described in the following chapter, Chapter 4: The Survey Development Phase.

CHAPTER 4

SURVEY DEVELOPMENT PHASE

Developing an Instrument to Quantitatively Identify the Different Ways of Thinking About Future Possible Careers

4.1 Purpose

The purpose of the Survey Development Phase is to refine an instrument to quantitatively measure characteristics identified from the Exploratory QUAL Phase. Using an instrument in research that does not assess what the researchers are presuming to measure can lead to incorrect results and wrong decisions (DeVellis, 2012). We refined a pre-existing instrument, the Motivations and Attitudes in Engineering (MAE) survey (Benson et al., n.d.). In refining the MAE survey, we were careful throughout the process of choosing factors, developing items, and testing for validity and reliability. To refine the survey instrument, we developed items and

tested for validity and reliability of the instrument. The instrument is being developed with the intention to use in the following phase of the study (Chapter 5: Exploratory QUAN Phase), where different ways of thinking about the future will be identified through a cluster analysis.

4.2 Results and Discussion

Factors and Items

Several code categories emerged in Chapter 3, The Exploratory QUAL Phase, that characterized students' ways of thinking about the future which served as the starting point for developing factors to include in the quantitative instrument. The factors were narrowed down based on what was needed to distinguish the three groups; constructs that were redundant across groups were identified and excluded from the survey refinement process. The final factors included in the survey, the meaning of a high factor score, abbreviations for the factor and the expected means for each cone type are listed in Table 4.1.

There were concerns with Cake Cone respondents being able to answer the ideal and avoided items because the questions may have imposed an ideal, avoided, and realistic future possible self that the participant did not have. The means for Cake Cone for ideal and avoided are listed as "Not Applicable" (N/A) for this reason.

Table 4.1 Hypothesized Means for Each Factor within Clusters

Factor	High Score Definition	Sugar	Waffle	Cake
Depth of future goals	The student is setting goals deep (about 10 years) into the future.	High	Medium	Low
Number of Future Possible Careers	The student can imagine many different future possible selves.	Low	Medium	High
Alignment of Realistic and Ideal Future Possible Careers	The student has the same realistic and ideal future possible selves.	High	Low	N/A
Alignment of Realistic and Avoided Future Possible Selves	The student has the same realistic and avoided future possible selves.	Low	High	N/A
Effect of Future on Present	The student believes the future has a high impact on what the student does in the present.	High	Medium	Low
Perceived Instrumentality	The student views what they are doing in the present as useful.	High	Low	High

The content validity of the items was improved by the experts in the field and through focus groups. An expert in Future Time Perspective theory pointed out that our some of our items intended to measure depth were measuring how well-defined students were thinking of their future. Additional items were added that appropriately measured depth. The focus groups revealed how students were interpreting the items, what items were unclear to the students, and why those items were unclear. From these focus groups we found that some words were being interpreted differently; for example, "explore" was interpreted as thinking about doing something, where "consider" meant a more active pursuit of something. The items were changed accordingly and reassessed by the experts to develop a final list of items. These items can be seen in Appendix K.

Pilot Study: Exploratory Factor Analysis

The resulting survey was completed by students in a sophomore level IE course (*n=187*). The results from the survey were used to test for internal consistency reliability. The EFA showed that the items did not load well into six factors. After removing items that did not load and running an EFA for five factors (Appendix N), the final factors were determined to be the five described in Table 4.2.

Table 4.2 The Resulting Factors from the EFA and Their Corresponding Cronbach's Alpha

Factor	Definition of High Score	Number of Items	Alpha (α)
Clarity of Future Possible Careers	The student has well-defined description of their future possible career.	5	0.82
Depth of Future Goals	The student is setting goals deep (about 10 years) into the future.	3	0.71
Alignment of Ideal and Realistic Future Possible Careers	The student has a positive outlook about the future.	9	0.86
Effect of Future on Present	The student believes the future has a high impact on what the student does in the present.	5	0.87
Perceived Instrumentality	The student views what they are doing in the present as useful.	5	0.84

The items that we hypothesized would load into one Depth of Future Goals factor, loaded into two factors: Depth of Future Goals and Clarity of Future Possible Careers. As pointed out by one of the experts we consulted with, some of the items intended to measure Depth of Future Goals were actually measuring how well-defined their future goals are. The Number of Future Possible Careers items did not load onto any factor, and those items were removed. The items in the two Alignment factors loaded

as one factor, Alignment of Ideal and Realistic Future Possible Careers. Three items were removed from the Effects of Future on Present; and Perceived Instrumentality stayed the same. For details of the items and factors see Appendix K.

Note that in Table 4.2, Cronbach's alpha (α) for each of the final factors was within the acceptable range, $\alpha > 0.7$. The final factors align with the results of Chapter 3, The Exploratory QUAL Phase; the inclusion of the Clarity of Future Possible Careers factor fits better with our understanding of the three groups, since participants in the Cake Cone group describe their future possible careers in very broad terms. Although participants in this group would not describe specific goals beyond graduation, it is possible they will conceptualize their future possible careers with very little clarity beyond graduation. The Depth of Future Goals factor may not be as informative, as indicated by the lower α, for distinguishing Cake Cone. The single Alignment of Future Possible Careers factor also seems to fit with the characterization of the different groups in Chapter 3.

Pilot Study: Cluster Analysis

A k-means cluster analysis was used to identify the different ways of thinking about the future. A three cluster model was the best fit for the data, based on the results of the scree plot (Appendix N) and based on the results of Chapter 3, the Exploratory QUAL Phase, in which three different groups (cone types) emerged. Each of the final factors were used to cluster the participants into three clusters. The clusters are shown plotted on the discriminant coordinates (dc), as shown in Figure 4.1. The

means of each of the factors in each cluster is shown in Table 4.3. Each of the clusters was identified as a group, as described in Chapter 3, The Exploratory QUAL Phase, where the means of the factors fit with the hypothesized means (Table 4.3).

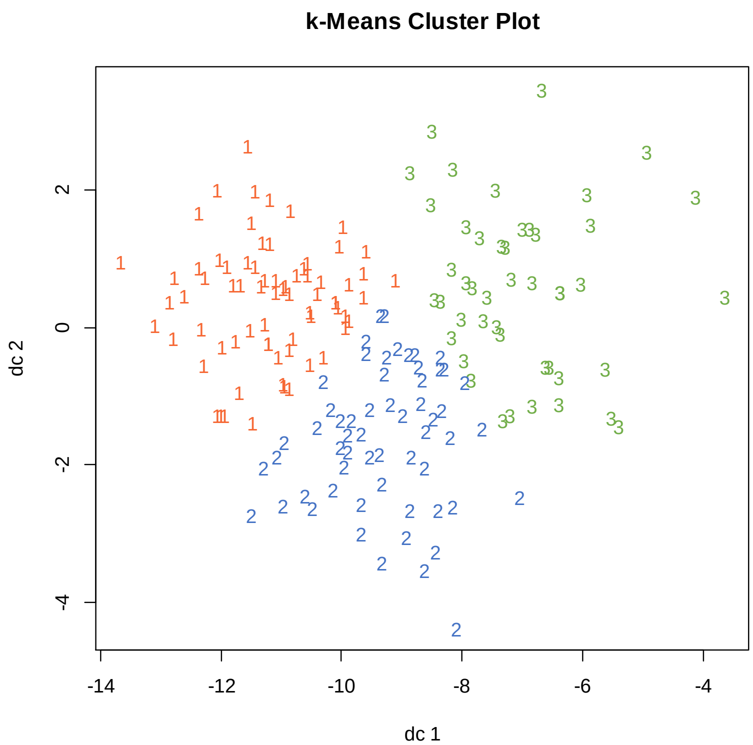

Figure 4.1 The Plot of the Cluster Analysis, where each of the green numbers indicates individual participants and the shaded circles indicated clusters (1=Sugar Cone 2=Cake Cone 3=Waffle Cone).

Pilot Study: External Validation

Finally, three of the survey respondents who had agreed to participate in follow-up interviews, were interviewed following the same protocol as used in Chapter 3, The Exploratory QUAL Phase. These participants, Nikki, Thomas, and Helen are described in Appendix C and in the following sections.

Table 4.3 Means of the Factors for Each Cluster and Interview Participant in the Survey Development Phase

Factor	Sugar	Cake	Waffle	Nikki (Sugar)	Thomas (Cake)	Helen (Sugar)
Clarity of Future Possible Careers	5.27	2.98	3.28	5.2	6	5
Depth of Future Goals	5.86	5.72	3.25	5.33	7	7
Alignment of Ideal and Realistic Future Possible Careers	5.65	4.79	4.30	5.33	5.89	5.78
Effect of Future on Present	4.55	4.33	4.10	5	6.4	6.4
Perceived Instrumentality	4.24	4.20	4.10	4.4	4.4	6

Nikki (Sugar Cone)

Nikki is a sophomore in BME, and she describes her future goals with definition and depth into the future. She describes her ideal and realistic future with detail as working in tissue engineering, preferably working at least one year in Germany, and eventually developing her own patent. and is working towards getting internships and experience working in tissue engineering. She describes her future possible career in detail; however, compared to the participants in Sugar Cone in Chapter 3 (pg. 64), The Exploratory QUAL Phase, there is a little less detail, which fits with here quantitative scores (definition of future career: 5.2 out of 7).

She describes the steps that she is taking now to reach her goals of working in tissue engineering by looking for internships in that field. She is also working towards being qualified to work abroad by staying involved in a student organization that travels to developing countries and uses engineering to improve the quality of life in communities in these countries. These descriptions indicate that her perceptions of the future are affecting the decisions she makes in the present (Effect of Future on

Present: 5 out of 7). The fact that she narrowed down her future goals and is able to describe these goals beyond her first job after graduation fits with other Sugar Cone students;

Nikki is motivated to keep a high GPA to stay qualified for the jobs she wants after graduation. She goes on to describe that if she learns the material she'll be able to achieve those goals even without a high GPA. This is driving her to work hard in her classes, particularly her classes related to tissue engineering to learn as much as possible, which demonstrates her perceived instrumentality of her current coursework. She has a narrowed perceived instrumentality for material related to tissue engineering, indicating that the course she completed the survey in, Sophomore Seminar in Industrial Engineering may not be as useful for her future (Perceived Instrumentality: 4.4 out of 7).

Thomas (Cake Cone)

Thomas is a sophomore in IE, and his main focus is graduating with his IE degree. He has a high number of future possible selves; he can see himself as a manager at a "typical" nine to five job in manufacturing, a healthcare setting, construction, business or any other IE field. This is characteristic of Cake Cone students, as well as the ability to talk about characteristics of his future career without one set finite goal. His future desired possible career involves working with people, being able to help people, using his IE degree, and not having to sit at a desk all day. Thomas's interview description

is not consistent with his quantitative scores (Clarity of Future Possible Careers: 6 out of 7, and Depth of Future Goals: 7 out of 7).

Also consistent with Cake Cone, when asked about any jobs he would not like to do, he described careers outside of his major, IE—working in fast food. He describes a wide range ideal future possible careers, which are also realistic, “I’m not really set on one thing [career], I have like a broad spectrum, so I’m fine with going—if I have to go like construction route, or business route, or healthcare route I’m not going to phase away from it.”

Participants in the Cake Cone group do not focus on the way the future is affecting the present, but rather focus more on how the present connects to the future. Thomas acknowledges how the present influences his future, but not the reciprocal: “I think the goals you set in the future can be affected by the things you do now.” His high score in Effect of Future on Present may have been a result of interpreting the items as how the present affects the future (Effect of Present on Future: 6.4 out of 7).

Although Thomas’s interview responses were inconsistent with what we would expect based on his quantitative scores, ultimately, he was placed in the Cake Cone group because that is consistent with how his interview responses were interpreted.

Helen (Sugar Cone)

Helen, a sophomore in IE, describes her future career with definition and depth into the future, with the steps she plans on taking to reach one specific future goal; this fits with the

description of a Sugar Cone student. She wants to get an IE degree, work for a consulting company (most likely be with Company X, because she has connections at that company) at the entry level then work up the management ladder. Her ideal and realistic future career is to become the CEO of a Fortune 500 company in 25 to 30 years; she describes the outcome of this as “being successful” (Depth of Future Goals: 7 out of 7 and Clarity of Future Possible Careers: 5 out of 7).

She does not see her IE classes as important for her future except that they will get her an IE degree. She has endogenous perceived instrumentality in her management classes. Her higher perceived instrumentality of the course she completed survey, Sophomore Seminar in Industrial Engineering, in may indicate that she identified aspects of the course as relevant to management (Perceived Instrumentality: 6.4 out of 7). Her future influences how she acts in the present—she is constantly trying to boost her resume and keep her GPA above a 3.5 because that’s what companies look for (Effect of Future on Present: 6.4 out of 7). Helen’s interview responses are consistent with what we would expect for a participant in Sugar Cone, and her survey results also place her in the Sugar Cone group.

4.3 Implications and Next Steps

Survey validity and reliability testing is a long and iterative process; this study was the first iteration with promising results and directions for improvements for the next Phase, Chapter 5, the Exploratory QUAN phase. The EFA resulted in five factors, all with Cronbach’s alphas of over 0.7 and four of which had Cronbach’s alphas over 0.8,

indicating that the items within the factors are measuring one underlying construct. These five factors are characteristics of students' ways of thinking about the future and the influence of the future on the present as identified in Chapter 3, The Exploratory QUAL Phase. As with any instrument, more work remains to develop items related to the desired constructs, and to refine the wording to most closely align with students' descriptions of their experiences from the qualitative data.

To improve the survey validation in future phases, I will include questions in the interview protocol to gain a better understanding of how the quantitative scores relate to the qualitative interpretations in Chapter 7, the Explanatory QUAL Phase.

CHAPTER 5

EXPLORATORY QUAN PHASE

Quantitative Identification of the Different Ways of Thinking About Future Possible Careers

5.1 Purpose

In the previous chapter (Chapter 4), we established validity and reliability evidence for a survey instrument intended to measure the characteristically different ways of thinking about the future. In this chapter, The Exploratory QUAN Phase, I use this instrument to quantitatively measure the different ways of thinking about future possible careers with a broader population of students in large-enrollment mid-year engineering classes. In this phase, I address the research question: "What are the quantitatively different ways mid-year engineering students are thinking about their future possible careers, how are these characteristic ways of thinking distributed, and are the characteristic ways of thinking about the future related to academic or social demographics?"

The survey was distributed electronically to 746 students at five institutions (Appendix B) over two semesters. Since some adjustments were made to the survey after the pilot, and since the participants in this survey are similar to the participants with which the survey was tested with an exploratory factor analysis (Chapter 4, pg. 83), a confirmatory factor analysis (CFA) was used to test that the theoretical model was a good fit with the data used in this phase. To identify the different ways of thinking about the future, a k-means cluster analysis was run. Multiple chi-squared tests for independence were used to identify if there is a relationship between different social and academic demographics and the identified clusters. If the chi-squared test was significant, it was followed by a MANOVA to compare the means of three different constructs across the demographic groups. All R code is included in Appendix N and the results are detailed below.

5.2 Validity and Reliability

Listwise Deletion

Missing data were removed using listwise deletion; every participant who skipped an item was removed from the survey. Listwise deletion was used as opposed to multiple imputations to handle missing data and due to the nature of the electronic survey distribution: students were prompted to answer a question if they skipped it accidentally, thus they had to make a conscious effort to skip an item. Multiple imputation is a robust method to replace missing values with a plausible estimate based on the participant's responses on other items (Graham, Olchowski, & Gilreath,

2007). However, because participants intentionally skipped that item, there is a strong possibility that there was something about that item that that student interpreted differently than the other items in the factor, and a multiple imputation estimate may not be appropriate.

One major concern with listwise deletion is that it biases the results based on who does or does not respond to all items (Potvin et al., 2017) . In this sample, twenty-one participants were removed using listwise deletion (*n=767* before deletion, *n=746* after deletion). The data were checked to determine if specific items were systematically skipped, and no item was skipped by more than 3 of the 767 participants. Also, a look at the demographics for the 21 participants removed, showed no obvious patterns in demographics.

Also note that some items were negatively worded (i.e. "I am unsure what my future career will be."), which were reverse coded.

Tests for Normality

Certain tests, including the confirmatory factor analysis (CFA), require an assumption of normality. To test that these data fit the assumption of normality required for further testing, the skew and kurtosis was checked for each item. Skew and kurtosis for all items were within the acceptable range ($|skew| < 2, kurtosis < 7$) (pg. 37). Scatter plots also indicated a fairly normal unimodal curve with a slightly negative

skew yet still within the acceptable range for normality assumptions (see Appendix N for plots).

Internal Consistency Reliability

Cronbach's alpha (α) and the covariance matrix were used to test for internal consistency reliability, or how interrelated the items within a factor are, indicating that the items together are measuring one underlying construct (Cho & Kim, 2015; DeVellis, 2012). The definitions for the factors and the constructs they are intended to measure are shown in Table 5.1. The Cronbach's alphas for each of the factors is shown below in Table 5.2. Five of the factors were within the acceptable range of $\alpha >$ 0.7; Value of the Future (α=0.54) and Exogenous Perceived Instrumentality (α=0.63) were both below the cutoff. The covariance matrix for all factors then showed that the covariances were not all below the lowest alpha (<0.54) (see Appendix N for the full covariance matrix). Value of the Future and Exogenous Perceived Instrumentality were then removed from further analysis. A new covariance matrix with the remaining five factors indicated covariances all well below the lowest alpha.

Table 5.1 Definition of the Survey Factors

Factor	A high score indicates…
Clarity of Future Possible Careers	The student has a well-defined future goal, deep into the future.
Alignment of Future Possible Careers	The student has an ideal future possible career that is also realistic.
Perceptions of the Future in Engineering	The student is certain about wanting to be an engineer.
Effect of Future on Present	The student recognizes that their future goals affect what they do in the present.
Endogenous Perceived Instrumentality	The student finds their course useful for their future career.
Exogenous Perceived Instrumentality	The student finds their course grade to be useful for their future career.
Value of the Future	The student perceives that there is value in thinking about long-term goals.

Table 5.2 Cronbach's Alphas for Each of the Factors. Exogenous Perceived Instrumentality and Value of Thinking About the Future were removed from further analysis.

Factor	Cronbach's Alpha (α)
Clarity of Future Possible Careers	0.85
Alignment of Future Possible Careers	0.78
Perceptions of the Future in Engineering	0.80
Effect of the Future on Present	0.72
Endogenous Perceived Instrumentality	0.87
Exogenous Perceived Instrumentality	0.63
Value of Thinking About the Future	0.54

Confirmatory Factor Analysis

A confirmatory factor analysis (CFA) was needed to test the model determined in the exploratory factor analysis (EFA) in Chapter 4, The Survey Development Phase. The

EFA helped in determining the underlying latent variables in the instrument, and the CFA allows us to confirm the fit of that model.

The CFA was then run with the proposed model with the five remaining factors (Effect of Future on Present, Endogenous Perceived Instrumentality, Clarity of Future Possible Careers, Alignment of Future Possible Careers, and Perceptions of the Future in Engineering). A one-factor CFA was run for a relative comparison for key CFA measures as explained in the Detailed Research Methods (pg. 37). All minimum requirements were met with the proposed model. The proposed model was a much better fit than the one-factor model was a much which showed a drastic increase in the chi-squared test statistic (χ^2) and a small increase in degrees of freedom (df). Both the indexes and the relative comparison indicate that the proposed model is a good fit (Table 5.3). All CFA summary statistics are included in Appendix N.

Table 5.3 Confirmatory Factor Analysis Model Fit. Compares the proposed model to a one-factor model.

	Chi-Squared		Fit Indexes		Measure of Error	
	χ^2	**df**	**CFI**	**TLI**	**SRMR**	**RMSEA**
Proposed Model	975.0	220.0	0.894	0.879	0.066	0.058
One-Factor Model	4147.9	230.0	0.453	0.398	0.146	0.151

5.3 Results and Discussion

Participants

Of the students contacted, 746 students from five institutions completed the survey and consented to participate in the study. The distribution and proportion of all

responses by institution are as follows: University A (*n*=14; 1.9%), University B (*n*=55; 7.4%), University C (*n*=292; 39.1%), University D (*n*=274; 36.7%), and University F (*n*=111; 14.9%). University C and D make up 75.9% of the participants; these institutions are both large and selective, with high undergraduate enrollment and the highest (C) or higher (B) research activity. A full description of the participating institutions is in Appendix B.

Participants were primarily mid-year (*n*=506; 68.8%) engineering (*n*=732; 98.1%) majors born in the US (*n*=679; 91.1%), who identify as White (*n*=535; 71.7%), male or cis-male (*n*=562; 75.3%), or heterosexual (*n*=712; 95.4%). Note that not all participants filled out every demographic question; these students are marked as N/A, indicating no information is available and are still included in the denominator of the proportions. (All proportions are taken out of the full number of 746 participants.) Compared to the nationwide demographics for engineering students for 2016 (Yoder, 2016), participants who identified as White (71.7% of sample vs. 63.4% nationwide) or female (24.0% vs. 20.8% nationwide) are slightly overrepresented; the sample is representative of residency or nationality (91.1% vs. 90.4% nationwide). These racial and ethnic demographics are more representative of the individual universities, all of which rated relatively low on ethnic diversity (U.S. News and World Report, 2017).

Cluster Analysis

To identify the quantitatively different ways of thinking about the future, a cluster analysis was run with the three non-context dependent factors: Clarity of Future Possible Selves, Alignment of Future Possible Selves, and Perceptions of the Future in Engineering.

The within sum of squares (WSS) plot indicated a significant drop in the WSS with k=2 clusters, and with a smaller drop with k=4 clusters. These drops are visible as “elbows” in the WSS plot (see Appendix N for plots). The results of the Exploratory QUAL Phase indicate the existence of at least three distinct ways of thinking about the future, so analysis proceeded with k=4 clusters.

The four clusters accounted for 62.1% of the total variance, and the silhouette width (plot shown in Appendix N) was 0.29 indicating a weak fit. A MANOVA was then used to test that these clusters are meaningful around our desired constructs. Both the total variance and silhouette width indicate a weak fit with the data, and the principle component plot does not show any obvious groupings. However, the silhouette indicates some structure in the data, and a MANOVA and the follow-up t-tests indicated that the four clusters identified in the k-means cluster analysis were highly significantly different across all factors at the 99.9% confidence level, indicating that these four groups do distinguish different ways of thinking about the future (Appendix N). These statistical tests and the qualitative results indicate there are meaningful groups differentiating between characteristic ways of thinking for mid-

year engineering students. Per the research objective and philosophy, it is beneficial to describe ways of thinking as meaningful groups for researchers and practitioners to understand.

The alternate clustering methods that were tested (Ward's, Partitioning Around Medoids, Median, and Centroid Hierarchical) demonstrated a worse fit with the data and resulted in clusters that did not fit with the theoretical understanding or previous qualitative results (Appendix N). K-means was the most appropriate method for these data and the research question; analysis moved forward using the four resulting clusters. Figure 5.1 shows the clusters plotted on the discriminant coordinates (dc).

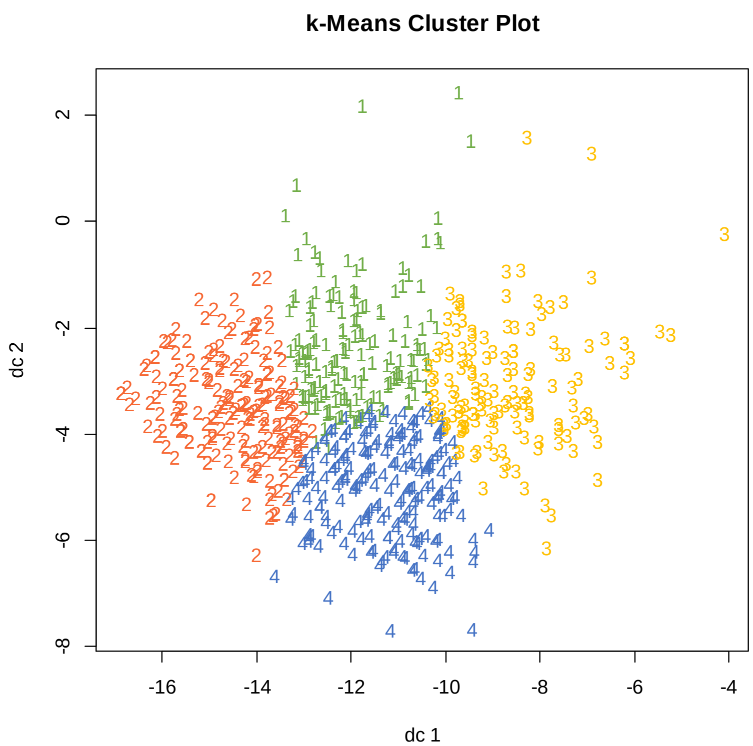

Figure 5.1 K-Means Cluster Plot. The four resulting clusters from the k-means analysis are plotted on the discriminate coordinates (dc).

Four Different Ways of Thinking About the Future

Shown in Table 5.4, a k-means cluster analysis with k=4 clusters, resulted in four clusters with the average factor scores for the non-context dependent factors that were used in the cluster analysis and the context dependent factors used to further describe these different clusters. The cluster analysis identified four different ways of thinking about the future; three of these clusters fit with what we would expect the quantitative scores to be for the three different ways of thinking identified in the Exploratory QUAL Phase (Chapter 3).

Table 5.4 Average Cluster Scores The darkest color indicates scores in the fourth percentile of the factor, the second darkest indicates the third percentile (above the median has white text), the second lightest the second percentile, and the lightest the first percentile (below the median has black text).

	All n=746	Cluster 1 n=176 (Waffle)	Cluster 2 n=210 (Sugar)	Cluster 3 n=141 (New)	Cluster 4 n=219 (Cake)
Clarity of Future Possible Careers	4.27	4.90	5.66	2.91	3.29
Alignment of Ideal and Realistic Future Possible Careers	5.16	4.93	6.07	3.87	5.28
Perceptions of the Future in Engineering	5.53	5.04	6.40	4.22	5.94
Effect of Future on Present	4.71	4.55	5.17	4.26	4.67
Endogenous Perceived Instrumentality	5.18	4.83	5.25	4.81	5.38

Cluster 2 shows high scores for everything except endogenous perceived instrumentality, which quantitatively represents the well-defined future possible career that is both ideal and attainable, with their perception of the future having an impact on the present and therefor limiting their endogenous perceived instrumentality to only the contexts relevant to their clearly defined future possible

career. Cluster 2 then is quantitatively representative of the Sugar Cone group previously identified in Chapter 3 (pg. 57). Cluster 1 has one of the highest Clarity of Future Possible Careers scores while also having lower Alignment of Future Possible Careers. These scores quantitatively demonstrate a well-defined ideal future possible career which is not attainable, consistent with the qualitative description of Waffle Cone.

The low Clarity and the higher scores in Alignment, Future in Engineering, and Endogenous Perceived Instrumentality in Cluster 4 are indicative of the broad, yet optimistic perceptions of the future seen in Cake Cone. The higher Effect of the Future on the Present score is inconsistent with the qualitative understanding of Cake Cone; however, as was during the external validation in The Survey Development Phase (Chapter 4, p. 85), it is possible that the Effect of the Future on the Present items are being interpreted as Effect of the Present on the Future by participants with this Cake Cone way of thinking about the future.

Cluster Analysis Identified a Fourth and New Group

Cluster 3 has statistically significantly lower scores than the other three clusters in all of the factors. This cluster demonstrates scores that were not encountered thus far in the qualitative strand; however, the existence of this cluster does theoretically make sense. There is a group of engineering students who do not have a clear idea of what their future career will be and believe that they will not be able to achieve an ideal career.

Distribution of Clusters

Next, how the distribution of these engineering students in mid-year engineering courses, across these clusters was explored. Due to the contextual and cultural roots of future oriented motivation (Bond & Smith, 1996), we may expect differences in these ways of thinking about the future across demographics. Understanding the distribution and the distribution across different academic and social demographics will help provide some insight into the relationship these ways of thinking have with these different demographics. The number of participants is not evenly distributed across clusters; there are more participants in Cake (Cluster 4; 29%) and Sugar (Cluster 2; 28%) Cone than the New cluster (Cluster 3; 19%) and Waffle Cone (Cluster 1; 24%). A Chi-Squared Goodness-of-Fit test demonstrates that these proportions are significantly different than an evenly distributed proportion (25% for each cluster; $p = 0.0001$ ***). This distribution fits with what might be expected of students in mid-year engineering courses, with participants primarily having an optimistic view of the future, that is in varying degrees of definition.

Relationship between Thinking About the Future and Year in School

Although we may expect students to develop a more clear and aligned perception of their future possible career as they progress in their academic career, it is interesting to consider how participants at various academic years in school, who are in second year engineering courses, are perceiving the future. The relationship between year in school and ways of thinking about the future were explored. Table 5.5 shows the

percentage of participants within each cluster who are first-year, sophomore, junior, or senior.

Table 5.5 Distribution of Clusters Across Various Academic Years. The percentage of first-year, sophomore, junior, and senior students, in each of these clusters is compared to the distribution of these clusters across all participants.

	Waffle	**Sugar**	**New**	**Cake**
All	24%	28%	19%	29%
First-Year	29%	29%	16%	26%
Sophomore	20%	27%	20%	32%
Junior	21%	32%	18%	29%
Seniors	44%	12.5%	31%	12.5%

It was a little surprising to see that fewer seniors (12.5%) were in Sugar Cone while many more were in the New cluster (31%). The relationship between clusters and year in school was tested using Chi-Squared Test for Independence, and it was found that the year in school was not independent from the clusters ($p = 0.00679$ $**$ based on results calculated in Excel®). Since this test shows some relationship between year in school and the characteristic ways of thinking about the future, the test was followed up with a MANOVA; from the MANOVA (Wilks; $p = 0.01302$ *), it was identified that the Alignment of Future Possible Careers was significantly lower than the average Alignment scores for first-year, sophomore and junior students. In fact, although not significant in some cases, an overall trend in a decrease in Alignment can be seen by year, as shown in Table 5.7.

Although we are seeing some significant differences in the perceptions of the future for seniors, it is important to note the context in which these data were collected. The

seniors in this study were currently enrolled in at least one sophomore-level engineering courses. The seniors in these courses may have a very different perspective of their future than seniors in senior-level engineering courses. Shifts in perceptions of the future over time will be explored further in the Explanatory QUAL Phase (Chapter 7).

Table 5.6 Average Clarity, Alignment, and Perceptions of the Future in Engineering Scores for each Academic Year. There is an overall trend in a decrease in Alignment of Ideal and Realistic Future Possible Careers score.

	Average Clarity	Average Alignment	Average Future in Engineering
First-Year	4.36	5.22	5.47
Sophomore	4.17	5.18	5.56
Junior	5.09	5.09	5.62
Senior	4.65	4.65	5.20

Table 5.7 Results Test for Significant Differences in Average Alignment of Ideal and Realistic Future Possible Careers (μ_{AL}) Across Year in School. The MANOVA showed a significant difference in the Alignment score by year, which was followed by t-tests.

	Sophomore $\mu_{AL} = 5.18$	Junior $\mu_{AL} = 5.094$	Senior $\mu_{AL} = 4.65$
First-Year $\mu_{AL} = 5.22$	t=0.4222, df=427.03, *p*=0.6731	t=1.193, df=338.22, *p*=0.2338	t=3.086 df=41.81, p=0.003584 **
Sophomore $\mu_{AL} = 5.18$	—	t=0.916, df=315.23, *p*=0.3599	t=2.961, df=37.75, p=0.005274 **
Junior $\mu_{AL} = 5.094$	—	—	t=2.329, df=46.39, *p*=0.02428 *

Relationship between Thinking About the Future and Major

There may also be some differences in the way the future and future careers are discussed or viewed for different engineering majors. Looking at the percentages of

participants with different engineering majors in different clusters shows more interesting trends. There is a wide range of percentages in Waffle Cone across different majors. There is a low percentage of participants in EE or ECE who fit into Waffle Cone (18%) and the New cluster (18%) particularly compared to CE (30% Waffle) and ME (23% New). A Chi-Squared Test for Independence indicates that there may be some relationship between major and cluster, although it is not strong (p=0.048 * results calculated in Excel®).

Table 5.8 Distribution of Clusters Across Various Majors. Distribution of clusters across various majors—Civil (CE), Electrical (EE) or Electrical and Computer Engineering (ECE), Mechanical (ME), engineering majors not CE, EE/ECE, or ME (Other Engr), and non-engineering majors (Non-Engr)—was compared using percentages.

	Waffle	Sugar	New	Cake
All	24%	28%	19%	29%
CE	30%	29%	18%	23%
EE	15%	29%	18%	37%
ME	22%	24%	23%	32%
Other Engr	25%	31%	17%	27%
Non-Engr	50%	22%	14%	14%

Relationship between Thinking About the Future and Race/Ethnicity

It also might be expected that perceptions of the future would be related to diversity factors, such as race and ethnicity. The distribution of clusters was compared across various races/ethnicities in Table 5.9. Most notably, there was a large percentage difference for participants who identified as Asian (34%) in the New cluster than may be expected based on the percentage for the entire sample (19%). Also noticeable is

the high percentage of participants identifying as Hispanic in Sugar Cone (42%) and low percentage in the New cluster (12%).

Table 5.9 Distribution of Clusters Across Different Races/Ethnicities. The distribution of the four clusters was compared across various races: White, Asian, Black or African American, and Hispanic, Latino or Spanish Origin.

	Waffle	**Sugar**	**New**	**Cake**
All	24%	28%	19%	29%
White	23%	29%	17%	30%
Asian	27%	12%	34%	27%
Black	21%	29%	17%	33%
Hispanic	27%	42%	12%	19%

These observations were followed with a Chi-Squared Test for Independence. However, due to small sample sizes the population for which we can test for statistical significance are participants who identify as Asian, Asian-American, and part Asian. The chi-squared test for the Asian population compared to the non-Asian population showed some relation to being Asian and clusters (p=0.001 ***). A MANOVA also showed that there is some significance between being Asian and perceptions of the future (Wilks; p=5.828e-05 ***). Participants who identified as Asian, Asian-American, and part Asian had a significantly lower average Clarity, Alignment, and Future in Engineering scores as seen in Table 5.10.

Table 5.10 MANOVA Results for Comparing the Perceptions of Future Possible Careers for Participants Who Did and Did Not Identify as Asian. The test statistic (t), degrees of freedom (df), and p-value are also shown.

	Asian	Non-Asian	t	df	*p*-value
Clarity	3.93	4.31	-2.255	95.43	0.02639 *
Alignment	4.66	5.21	-4.57	96.37	1.446e-05 ***
Future in Engineering	5.19	5.57	-2.92	96.15	0.00435 **

5.4 Implications and Next Steps

The identification of the fourth cluster not previously identified in The Exploratory QUAL Phase (Chapter 3) drives a need for an Explanatory QUAL Phase (Chapter 7) to explore this fourth cluster, or way of thinking about the future, in more depth. Qualitative data will help determine if this fourth quantitative cluster is *qualitatively* distinct from the three ways of thinking previously identified (Chapter 3, The Exploratory QUAL Phase). To answer the guiding research question, if this fourth cluster is distinct from the previous three, it must be described in the same depth.

To qualitatively describe this fourth cluster, participants who quantitatively fit into this cluster at the time of the interviews must be identified. Since these constructs are expected to shift for individuals over time, we would want to interview participants as close to them completing the survey as possible. This drove the need for Chapter 6 the Follow-Up quan Phase, to identify participants to interview. The qualitative strands will provide more insight into the implications of the differences in the distribution of the clusters across all participants and by year, major, and race. The discussion of the distribution of these clusters continues in Chapter 8 (pg. 153).

CHAPTER 6

FOLLOW-UP QUAN PHASE

Quantitative Identification of Shifts in Perceptions of Future Possible Careers

6.1 Purpose

The purpose of this chapter, the Follow-Up quan Phase, is twofold: 1) to identify participants to interview in the newly identified cluster and 2) to explore how these four different ways of thinking shift over time. The research question for this phase is, "How do engineering students' perceptions of their future possible careers change over one year for students in sophomore level engineering classes?" In this chapter, the term "state" will be used to describe the characteristic way of thinking for a participant at any one time point. The term "state" emphasizes that these ways of thinking are not stagnant bins to place students into, but rather are describing a state of thinking at the time the participants completed the survey.

The participants who consented to be in the study in the Exploratory QUAN Phase (Chapter 5, pg. 96) (*n=746*) were contacted via email to complete the survey again (1-2 semesters later). The participants' ways of thinking were then identified in two time points: Distribution 1 (Chapter 5, The Exploratory QUAN Phase, pg. 96) and Distribution 2.

6.2 Results

Participant Description

The participants in this study are the 71 students for whom there is longitudinal data. These participants were students in sophomore-level CE, EE, and ME courses in Fall 2016 or Spring 2017. Of these participants, 65% identified as male, 34% as female, 72% as White, 8% as Asian, 1% as Black or African American, and 1% as Hispanic. Women are overrepresented in this sample compared to the national average for undergraduate engineering (19%) (Yoder, 2016).

Due to the low response rate (71 out of 746; 9.5%) and the small sample size, the longitudinal sample was compared to the larger sample for representativeness using Chi-Squared Goodness-of-Fit test and a Welch's two-sample t-test for equal means (Table 6.1). The sample was determined to be representative of the population in terms of race and ethnicity, gender, and the distribution of the four groups. Year in school and university are not well represented in the longitudinal sample. Most notably, a higher proportion of participants who were sophomores in Fall 2016 and

Spring 2017, the target population, responded in the second distribution (65%) than in the first distribution (44%).

Additionally, Welch's two-sample t-test for equal means showed that both the Clarity and Alignment of Future Possible Careers scores were not statistically different for the participants who did (*n=71*) and did not (*n=675*) complete the survey in Distribution 2, as shown in Table 6.1. Overall, there were no significant differences in participation by race or gender, but participants who were sophomores in Distribution 1, the target population, were more likely to respond to the second distribution, and thus are overrepresented in the longitudinal sample. With this limitation noted, the results of longitudinal analysis (*n=71*) is shown in the following sections.

Table 6.1 Representativeness of Distribution 2 (n=71) of Distribution 1 (n=746). Note that a small p-value indicates a significant difference between the two samples.

	χ2	**df**	***p*-value**
Year	13.111	3	0.0044*
University	19.319	4	0.0006**
Race	2.4323	4	0.6568
Gender	4.8952	2	0.0865
Cluster	3.6733	3	0.2990
Clarity of Future Possible Careers			0.2340
Alignment of Future Possible Careers			0.7129

Quantitatively Identifying Different Ways of Thinking About Future Possible Careers

The four clusters identified in Chapter 5, The Exploratory QUAN Phase (Table 5.4), can be distinguished with only two of the factors: Clarity and Alignment of Future

Possible Careers. The four groups are distinguishable using the four different combinations of average Clarity and Alignment scores above and below the mean for the factors identified in Chapter 5, The Exploratory QUAN Phase (Figure 6.1). There are some differences between means of Clarity and Alignment for the clusters in Distribution 1 and Distribution 2, as seen in Table 6.2. Again, these differences are non-significant as was indicated by Welch's two sample t-test (Table 6.1).

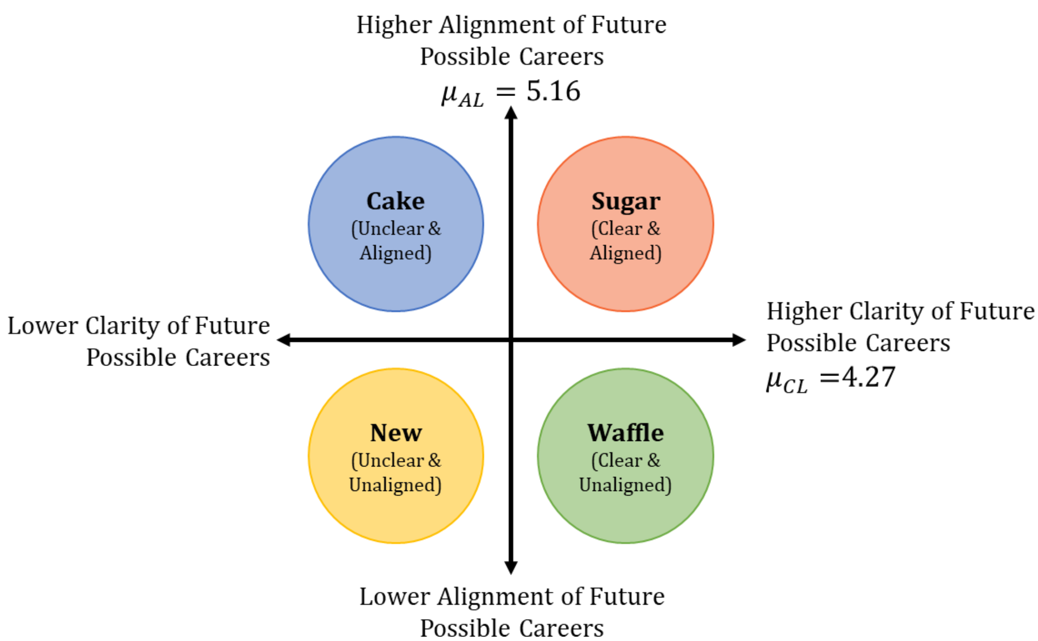

Figure 6.1 Four Different Ways of Thinking About Future Possible Careers Represented on a Quadrant. The Participants were identified in one of four states—Cake (unclear and aligned), Sugar (clear and aligned), New (unclear and unaligned), and Waffle (clear and unaligned)—based on their average Clarity (μ_{CL}) and Alignment (μ_{AL}) of Future Possible Career Score from Distribution 1.

Table 6.2 Averages for Clarity (μ_{CL}) and Alignment (μ_{AL}) of Future Possible Careers in Distributions 1 and 2

		All	Waffle	Sugar	New	Cake
Distribution 1	Clarity of Future Possible Careers	4.27	4.90	5.66	2.91	3.29
	Alignment of Future Possible Careers	5.16	4.93	6.07	3.87	5.28
Distribution 2	Clarity of Future Possible Careers	4.12	4.60	5.58	2.94	3.33
	Alignment of Future Possible Careers	5.35	5.00	6.31	4.22	5.52

Longitudinal Shifts in Groups

After the states at Distribution 1 and 2 were identified for each participant and the representativeness of the participants was demonstrated, the shifts were described using counts and proportions. The descriptive statistics describing these shifts are shown in Table 6.3. The most significant finding was that 52.2% (*n*=12) of the 23 participants who were in Cake Cone in Distribution 1 shifted to Sugar Cone in Distribution 2. Also, there were relatively high percentages of participants remaining in Sugar and New (43.8% and 47.1%, respectively) clusters. When observing the shifts to certain states (the columns in Table 6.3), note that there was only one participant shifting into Waffle and a large number of participants shifting into Sugar or New clusters from each of the Distribution 1 states.

Table 6.3 Description of Shifts of Ways of Thinking about Future Possible Careers Over Time. The single numbers indicate how many and the percentage of participants shifted from the row cluster at distribution 1 to the column cluster in distribution 2.

Distribution 1 \ Distribution 2	Waffle	Sugar	New	Cake	
Waffle	0 (0%)	5 (33.3%)	7 (46.7%)	3 (20.0%)	15 (21%)
Sugar	0 (0%)	7 (43.8%)	4 (25.0%)	5 (31.3%)	16 (23%)
New	1 (5.9%)	5 (29.4%)	8 (47.1%)	3 (17.6%)	17 (24%)
Cake	0 (0%)	12 (52.2%)	8 (34.8%)	3 (33.3%)	23 (32%)

n=71

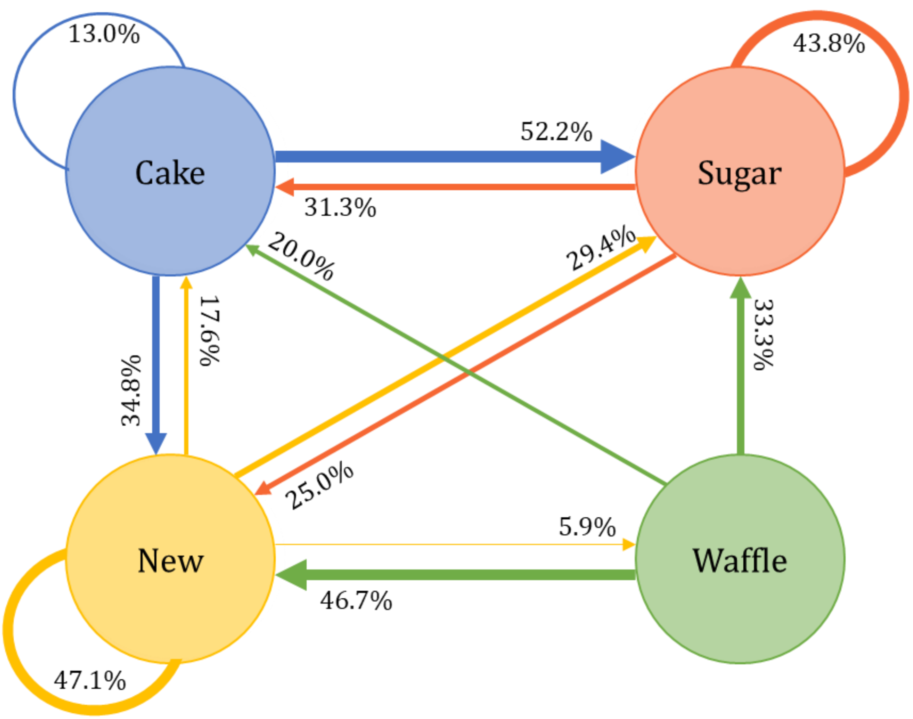

Figure 6.2 State Diagram of Shifts. Each circle represents one of the four characteristic ways of thinking about the future. Arrows of the same color leaving the circle represents the participants who shifted out of that state in Distribution 2. The thickness of the arrows is proportional to the percentage of participants who shifted out of that state.

6.3 Discussion

Although time orientation and future time perspectives is believed to be relatively stable at the domain-general level (Hilpert et al., 2012), these data demonstrate that beliefs about future possible careers shift over the academic career of individuals. The groups were identified through cluster analysis of what are considered as non-context dependent; note that here, non-context dependent is simply distinguishing the items that do not refer to a specific course but are still measuring a phenomenon dependent on the context of undergraduate engineering coursework. As students gain knowledge and experience as undergraduates, these ways of thinking are developing and changing.

Shifts into Sugar (Clear and Aligned)

Generally, we see a transition happening towards Sugar (Clear and Aligned, 29 of 71 participants) in Distribution 2, particularly from Cake (Unclear and Aligned, 52.2% of Distribution 2 participants), which fits with our understanding of those ways of thinking. A main goal of higher education, particularly in engineering, is to prepare students for their careers after graduation (Husman & Lens, 1999). As graduation approaches, students may be gaining a better understanding (Clarity) of their realistic and ideal future possible careers and resolving any conflicts between their mismatched future possible careers (Alignment) (Markus & Nurius, 1986).

The nine participants who shifted out of Sugar (Clear and Aligned) from Distribution 1 to 2 may have had an influential event or experience occur, such as an

undergraduate research experience or co-op; experiences such as these have been shown to influence students' perceptions of their future (Kirn & Benson, 2018; Paretti, Matusovich, Elkins, & Boynton, 2014).

Shifts Out of Waffle (Clear and Unaligned)

No participants in Waffle (Clear and Unaligned) in Distribution 1 remained there. The participants in Waffle in Chapter 3, the Exploratory QUAL Phase, described being conflicted between two future career paths: one that is desirable yet unrealistic and another that is realistic yet not ideal. It is possible that over time students resolve this conflict by either deciding on one career path, shifting them into Sugar (Clear and Aligned, 33.3%), or not finding a future possible career that is desirable, shifting into the New group (Unclear and Unaligned, 46.7%).

Shifts into New (Unclear and Unaligned)

Generally, we see a transition beginning to happen towards Sugar, which makes sense, but also towards the New group (Unclear and Unaligned, n=27). The lack of a qualitative description for this group makes it difficult to interpret results. Looking at the quantitative scores (Chapter 5, Exploratory QUAN Phase, Table 5.4), it can be seen that these students have less clarity of their future possible careers ($\mu_{CL} = 2.91$ out of 7) and a lower alignment of their ideal and realistic future possible careers ($\mu_{AL} = 3.87$) than the other four groups, and according to the t-tests these differences are significant (Appendix N). These scores are indicative of students who are not sure what they want to do in the future for their careers but believe whatever career they

do pursue is not likely to be enjoyable. These beliefs are not conducive to academic achievements (Fryer, Van den Broeck, Ginns, & Nakao, 2016), and it is concerning that a majority of participants who were in the new group (Unclear and Unaligned) in the first distribution remained there in the second distribution (47.1%). Participants who remained in the New group have not identified a future possible career that is realistic and desirable.

6.4 Implications and Next Steps

The shifts observed in this phase confirm the need to quantitatively identify participants shortly before they are interviewed. The data from this Follow-Up quan Phase were used to identify participants based on their average Clarity and Alignment of Future Possible Career scores ($\mu_{CL} = 5.16$ & $\mu_{AL} = 4.27$). These students were quickly recruited for interviews to qualitatively describe the differences identified quantitatively in the new group. Results from these interviews are described in Chapter 7, the Explanatory QUAL Phase.

CHAPTER 7

EXPLANATORY QUAL PHASE

Qualitative Description of Mid-Year Engineering Students with Unclear Future Possible Careers

7.1 Purpose

Four different ways of thinking about the future were identified in the Exploratory QUAN Phase (Chapter 5); the Exploratory QUAL Phase (Chapter 3) provided a qualitative description of three of these groups. The purpose of this chapter is to gain a deep and rich description of the new fourth group. The research question for this phase is, "How do students who have lower scores on quantitative measures of their clarity of future possible careers and conflicting ideal and realistic future possible career scores qualitatively describe thinking about their future possible careers?" Through answering this research question, we also describe how these students experience pursuing their engineering degree and the decisions these students are making with respect to their coursework.

Data were collected using a semi-structured interview protocol similar to that used in Chapter 3, the Exploratory QUAL Phase, with additional prompts on their background and survey validation at the end of the protocol (Appendix M). The interviews were coded using directed content analysis based on the resulting codebook from the Exploratory QUAL Phase (Appendix E). The results detailed below include additional codes that were identified, and the themes that emerged to describe the experiences of the participants. The discussion combines these different themes to answer the research question and tie in previous literature.

7.2 Results

Participant Description

In Spring 2017, I interviewed nine students, who were selected based on their quantitative scores as described in Chapter 6. One participant, Owen, was excluded from the analysis based on two considerations: 1) he was a senior who did not fit with the target population of this doctoral study and 2) he explicitly identified significant changes in his perceptions of the future between the time of completing the survey and the interview due to a career fair and his upcoming job search. This shift in Owen's perceptions is discussed further in Chapter 8 (pg. 157).

Of the eight participants included in the analysis, four identified as male and four as female (including one cis-female). Four participants identified as White, one as Hispanic, two as Asian, one as Asian and White. One participant identified as bisexual, and one participant identified as not being born in the United Sates. Descriptions of

the participants and their perceptions of the future are included in Table 7.1. The sophomore students are second-semester sophomores. The disproportionally high response rate from Asian and Asian-American students fits with our understanding of the distribution of race and ethnicities in the clusters (Chapter 6), in which a much higher percentage (33%) of participants who identified as Asian or Asian-American were in the new group than for the entire sample (19%).

Table 7.1 Description of Participants in Explanatory QUAL Phase. Participants are described using their pseudonym (Name), major, year in school (Year), university (Univ.) and a brief description of their perceptions of the future.

Name	Major	Year	Univ.	Perceptions of the Future
Amy	EE	Junior	C	• Aware of career options with an EE degree • Wants to use her degree to help people
Bill	ME	Junior	C	• Interested in roller coaster construction • Pursuing internship in gun manufacturing company or consumer manufacturing company
Derek	BME	Sophomore	F	• Wants to work in a lab space • Realizes that BME may not provide the lab opportunities he expected
Grace	EE and Dance	Junior	B	• Seeks a future with both EE and Dance • Is defining the best way to reach that future
Hannah	Cyber Engineering	Junior	F	• Intentionally avoids thinking about the future • Wants to save the country
Parker	ME and Aerospace	Sophomore	D	• Focused on studying abroad in Germany • Wants to help society colonize in space
Ryan	Textile Engineering	Junior	C	• Wants to coach or teach • Also wants to use his degree and make money
Selyne	EE	Junior	B	• Enjoys gaining a variety of experiences • Always wants to work on something new

Identification of New Codes

Consistent with directed content analysis, while coding I identified units of meaning relevant to the phenomenon of interest that did not fit well into a predefined code. These sentences or phrases were marked during the first cycle of coding and

considered together across all participants when determining an appropriate name and definition for each code. Therefore, results include several new codes, which provide insight into the qualitative description of this new group. The full codebook is included in Appendix E.

- *Expression of Fear:* The participant described a type of fear of the future, including how that fear was influencing what they were doing in the present.
- *Feelings of Being Stuck*: Participants described feeling stuck in their present, their future career paths, and their future possible careers.
- *Focus on Wellness*: The participant described wanting to focus on well-being, mental health, or wellness.
- *Alternative Future Possible Career*: The participant described a future possible career that was once possible for them in the past but is no longer attainable.
- *Conditional Future Possible Career*: The participant described a future possible career with a conditional statement—a future which is not possible given their current behaviors and path but could be possible given a change in behavior.

I then used these newly identified codes along with the *a priori* codes to form themes that describe the experiences of these participants. In the following section, I describe the themes identified with quotes from participants as evidence of these themes. Sections of the quote which emphasize the evidence of the themes are underlined, intended for ease of reading.

Themes

The results in this section include themes that emerged across the participants with quotes and examples from the interviews. The discussion further combines these themes to describe a holistic description of the ways these participants are thinking about the future. In Chapter 8, these themes will be discussed further in context to the entire doctoral work, including a comparison to the other three groups (pg. and the outcome space from the Exploratory QUAL Phase, Chapter 3.

Future Possible Careers Described as Characteristics and Pragmatic Outcomes

When asked about the future, participants described broad characteristics of their future possible careers, such as being on a team, innovating, and working in a lab space. Selyne described desired characteristics of her future possible career, "I want to be constantly intelligently stimulated in a creative environment."

In general, participants' descriptions of the future beyond graduation were undefined, although nearly all participants described their future career goals in terms of a desired *outcome* of their future possible careers. These outcomes were related to contributing to society or more personal objectives such as being financially stable. Hannah, who was majoring in cyber engineering, did not describe any characteristics of her future possible careers but did describe a desired outcome from her major and eventual career as saving the country. Parker described an even broader future career outcome of addressing large societal problems.

> Information warfare is getting to be a pretty big thing, and I'm not that into politics, but I would definitely like to maybe save the country, just not ... Without moving across the country or anything. Just from my computer wherever I am. (Hannah)

> Research helps innovate and it helps people and I think that's where my passion comes in is because that's the one thing that I have always wanted to do is help people and make sure that they are the best they can be because what I have done. (Parker)

The desired outcomes were often described as a balance between something the participants will enjoy, something that contributes to society, and something more practical such as earning a living.

> To either get a job, or something, to help sustain the lifestyle that I want. Like, if it pays ... The goal is to ... I don't care how much money I get, as long as it's enough for me to live, and do things that I find entertaining. Or things that I enjoy doing. (Ryan)

> My goals are kind of just to find something I enjoy that helps me earn enough money to just not have to really worry about financials and that stuff. (Amy)

Participants demonstrated a strong connection to wanting to use their degree to contribute to society but also struggle with finding a career that will also be beneficial to themselves by providing enjoyment and financial stability:

> Well, also like doing something that kind of contributes to like, I want to work with solar because climate change is an issue and like creating sustainable renewable energy sources is like something that has a huge benefit on the future. So, like <u>I want to do something that is beneficial to other people and also to me</u>. (Amy)

Discomfort with or Fear of the Future

Most participants showed a discomfort with having undefined future possible careers or experienced anxiety or fear when thinking about the future. Amy's initial reaction to being asked about her goals for the future was, "I'll be thirty, <u>that's scary</u>. I don't really know, like yeah, just having a decent job." Participants, such as Selyne described using the present to gain an idea of their many future possible careers. Selyne also demonstrated having a fear of narrowing down those future possible careers:

> Definitely [gaining a variety of experiences now] to help me narrow down because I am very good at generating a bunch of different paths because that's how my brain works. <u>Picking one, oh my God. It's horrible. It's terrifying</u>. (Selyne)

While Selyne had many ideas for her future, but was stifled by her fear of choosing one career to pursue, Hannah expressed not wanting to plan for the future to avoid being disappointed:

> I'm going to be working, but I don't want to plan too specifically, I guess, and have plans change or something. …I just ... <u>I don't want to be disappointed</u>, I don't want to have ... I don't want to go in with a preconception that's going to affect how I make my decisions and things. I don't want to say oh, I thought I was going to be here, so I'm going to say no to this. (Hannah)

Even participants who have a defined career path show discomfort with the *perception* of their future possible careers as undefined. For example, when asked "What are your goals for the future?" Grace responded, "Mine are kind of undefined at the moment." Then she continued to describe a well-defined future career path:

> Ideally, after college I will go and work in industry for a few years. I'm thinking about working ... I kind of want to focus on like MEMS and microsystems and circuits and stuff like that. Yeah, so I'll work in industry there for a while, and hopefully, I will also get to dance while I do that. Then after working in industry for a few years I think I will probably go back to grad school. Then after that I'm not really sure. … [In] 10 years, hopefully, I'll be working my way up through a

> company because I'd like to get to more higher-level positions. Probably I think I would probably be living in a bigger city like New York City or something like that. Yeah. (Grace)

Although her future career path was well-defined, she expressed a discomfort with the breadth of her future possible careers: "Yeah, just so that hopefully by the time I graduate my idea of what I want to do won't be so vague and it'll be more specific."

This fear or discomfort with the future for other participants seemed to result in the stunting of the participants' extension into the future. In general participants future goals did not extend beyond graduation. For example, when asked about 10 years into the future, Bill responded with ambiguity:

> In general. I see myself with a family, with a career. I don't know. <u>Hadn't really thought that far ahead</u>. (Bill)

Hannah simply responded that her goals for the future are "to end up with a job." This short extension was also demonstrated by the participants' focus on the present or near-future.

Extension to the Future Stunted at Near-Future

Often when asked about the future, participants described goals for the near-future, within that week or semester as opposed to jobs or careers after graduation. These goals were often focused on academics. Parker and Ryan described wanting to focus on being a good student:

> That is a good question. I think that...what I think I can be is I hope that I can be a good student. That's really all I have for the future right now is getting through school right now. (Parker)

> I guess, for the near future, kind of get back to my good study habits, because lately I've been feeling a lack of motivation. And that's hurt my grades a little bit. And in the far future, I guess, graduate college, with a good GPA, get a job, all that good stuff. And still be enjoying the process. Because now I'm starting to not enjoy it, so, I'm trying to find out ways to enjoy it again. (Ryan)

Note that Ryan's description demonstrates the extent of his extension into the future where the far future is graduation and a general idea of a job. Ryan described wanting to try to find a way to enjoy the present. Similarly, Parker described how important it is to be happy and enjoy the present: "Yeah, I think in my eyes, the journey is better than the destination." Often participants described their future goals as graduating or getting through the more near future.

> So those are my goals. It used to be get done with school and move away from here. Now it's just get done with school and then take it from there. (Derek)

> Right now, my main thing is graduating and finding a job right after I graduate. I guess I haven't really thought this far into the future. (Hannah)

Derek and Hannah both demonstrated being conscious of their short extension into the future, even demonstrating an intentional effort to not think beyond graduation. Participants described the workload in engineering as consuming their thoughts and motivations:

> I have just sort of...I haven't really gone much more into it [thinking about the future] because this semester I've been getting...the courses have been really...they're not technically hard, just the amount of time that I have to put in them because I am working full-time and trying to keep grades up is kind of keeping my full attention at the moment. Between that and studying abroad it is kind of difficult to think much further than that. (Parker)

> I think it's just the repetitive nature of the school. Because you wake up, go to class, do homework, and then finish the rest of your day. So, yeah. It's kind of like ... I just have to get motivated again. (Ryan)

Amy described her overall experience in engineering as “good but stressful.” She also echoed the coursework being time consuming:

> The amount of coursework we have, like projects and homeworks and that stuff. And it is a fairly difficult subject, especially now, like junior year is intimidating. So yeah, like <u>I tend to spend a lot of time worrying about when things are going to get done and when I'm actually going to have free time</u>. Yeah, but I do enjoy it, like I don't want to, I don't know. (Amy)

The participants' descriptions of workload were often accompanied by a desire to focus on the present and often wanting to focus on present well-being. Ryan described struggling with finding the motivation to do the work in his courses; he was currently trying to improve his grades by attending and being prepared for class:

> I've been losing motivation this semester, so I'm trying to work on ways to get that back up…<u>I'm trying to wake up</u> ... On Mondays, and Wednesdays, I have late class, but I'm trying to wake up when I'd normally wake up ... Like today, and Thursday, I have morning classes. So, wake up at the same time ... Or maybe just a little bit later, and <u>start doing homework, or study, before I have the classes</u>, and then go to class. It's hard to do, but "do it as soon as it's assigned" kind of mentality. Because right now, I kind of do it the day before, and it works out because the assignments aren't that long. But also, if I did the day before, then I'd have more time to just in case something changed. (Ryan)

Feelings Stuck or Fear of Being Stuck in Engineering

These descriptions of the workload were also accompanied by feelings of being stuck in engineering. These feelings of being stuck were based on financial reasons, or family pressures, but primarily driven by the time already spent in engineering:

> That's my main goal, just to finish hopefully within the next three years, give myself an extra year. Even if it takes longer, I'll just keep going. I wanted to switch majors for a long time, but now <u>I feel like I've got too far into it to… switch</u>…yeah. (Derek)

> I'm kind of thinking, because <u>I'm already this far in, I've got to get that degree</u>. Because it's from there, that opens up more doors than just not getting a degree. And so, yeah. My goal right now is to stay focused and get that degree. Because from there, if I do want to switch, it's much easier to switch than it would be to completely stop now, and then not get that. (Ryan)

Ryan continues to explain this feeling of being stuck in the context of the expectations of and his financial dependence on his family:

> He [brother] was kind of like someone who was very encouraging…He helped me get more independent. Even though you do have people to help you out, in the end, it's all up to you. And he switched out of engineering, and my parents weren't happy with it,

at first. But he said he didn't care. Because he wasn't enjoying it at all. Now he said he's much happier in his new major. And so I kinda feel like, I wish I had done that. Then I maybe would have found something that I was more interested in. Because if I switch too, my parents may have been real upset, and I didn't know exactly what I wanted to switch into yet. The only thing that I was told was engineering kind of thing. (Ryan)

This description of being stuck extended beyond feeling currently stuck to a fear of being stuck in the future.

(My fear is that I get an engineering degree, and something happens, and I am stuck in a job that I don't really care for and that's something that I am not really...I don't ideally want in life. (Parker)

Discussion of Future Possible Careers Without Agency

When describing future possible careers, participants could name many future possible careers that were possible because of their degree. These ideas of future possible careers came from conversations with peers, career fairs, or seminars. When asked about what careers Amy could achieve, she began to list careers using her fingers as if she was trying to recall a list. When I asked about the listing, she said, "Yeah, I think we had like a presentation, and it was like, these are the three like major areas [for careers in EE]." Hannah also described three options related to her major:

> I don't know [where I'll be working in 10 years]. Maybe working for the government, maybe a private cybersecurity firm, maybe an insurance company if I do the actuarial science route. Honestly, I don't know. (Hannah)

As she described this list, Hannah made no connection to these careers or expressed any judgement on them; these careers were simply ones that she knew were options based on her major. There was an awareness of the possible future careers and again a focus on using the degree that they were currently pursuing.

Also demonstrating a lack of choice or ownership, participants describe their future possible careers in terms of what will be most practical. Participants described these future possible careers in broad practical terms. The future possible career wasn't necessarily a goal in itself, but rather the most practical option to find a job they enjoy that also uses their degree. Parker described wanting to go to graduate school and ideally become a professor, because it is "the best way to go in the current state of the government and funding and everything that's one of the better ways to go." Seylne also demonstrated a very practical approach to her future possible career options:

> Figuring that out, <u>one option was the academic option</u> that is kind of get really into my research lab, get publications in, go down the PhD track and having to deal with that like, going and teaching and kind of build my own research lab or to be one of the four P.I.'s of a

> research lab. Another option is after, on a graduate level, probably I join a small business just because I know that's more my working style. Working on something interesting that I can contribute to. Probably start somewhere and move somewhere else just knowing how industry kind of works a little bit. You're not usually set in stone at one place but as I go through and figure out who I work really well with and then branch off, kind of, figure out the important people and where I work best and go from there to build that ideal team and do something awesome. (Selyne)

Selyne showed some idea of preference of her many options, but generally echoed her concern about choosing one path. Participants including Seylne described using academic experiences (seminars, career fairs, internships, and undergraduate research) to help them determine what their many options are.

Misalignment of Ideal, Realistic, and Avoided Future Possible Careers

When describing avoided future possible careers, participants described a career unrelated or that does not use their degree, such as working in a coffee shop (Grace). Hannah again listed a wide range of careers that she did not want to pursue:

> Oh, a lot of things. I don't want to be in charge of a large group of people. I don't want to be a public figure or a public speaker, or anything like that. Any type of politics. A lawyer, don't want to be a

> lawyer. I thought for a second I wanted to be a judge when I was little. Then I figured out you have to go to law school, which was, no. I never want to be a doctor. I can't handle blood. Along with that, a nurse, a physical therapist. Any part of that. I don't want to be an architect or an artist, or ... I never want to appear on a movie screen. (Hannah)

Parker describes his avoided career as being one where he doesn't use his degree:

> The thing that I want is having…to use my degree so I don't want to be in a profession that doesn't use the degree that I have attained if that makes sense. (Parker)

Not only did they describe their avoided future possible careers as those that don't use their degrees, these participants struggled with finding an ideal career that uses their degree:

> Long term, I would have to say [my goals are] to just find a job that I would actually enjoy in engineering. (Parker)

> Right now, I'm in textile engineering, so find something ... A career path in textiles that I enjoy. Because I'm getting into the more specific classes, but I still would like to learn more about it, just so I know what I'm getting into. So, yeah. (Ryan)

Ryan went on to describe his ideal career as being a coach or a teacher, and his avoided future as not being (financially) independent and not making enough money to support himself. He acknowledged that his ideal career, although it is realistic, would not allow him to make enough money, and would thus lead him to his avoided future:

> [My ideal future career is] probably a coach, or a teacher, something like that. But ... I don't know, teaching now, it sounds bad, but I know it's not going to pay enough for what I want to do. Because teachers are very undervalued here. (Ryan)

When describing realistic future possible careers, participants described their future possible careers as attainable given certain conditions: "I definitely can be an engineer. I just have to get motivated again to do it." (Ryan) Given a change in behavior or a change in their current path, their broad conceptions of the future were perceived as being possible. However, some participants described being past the point of the conditional statement, resulting in more of an impossible future possible career.

A Focus on The Past or Impossible Future Possible Careers

Participants undefined or lack of future goals may be related to having more of a time orientation focused on the past. For example, Ryan described what his responses to these questions would have been a year ago:

> So, yeah. Usually, if you asked me that question last semester, it would have been 100%, oh, yeah, my future goals are to graduate, so I want to work hard, and enjoy it while I'm doing it. But right now, it's kinda like, I want to work hard, but it's just not fun. So I'm not doing as well as I should. (Ryan)

This focus on the past also seems to be related to participants' feelings of being stuck in engineering. When asked about his goals for the future, Derek described what his future possible careers used to be, why he wanted to be a BME major, and how he now believed he had a misconception of BME:

> They have a biochemistry degree at the school I'm at. I'm in biomedical engineering and I guess when I got into it I thought it was more like that laboratory track where you work under somebody helping them do their research or whatever. But I think now that I've seen about half of it, I can tell its hardcore engineering which I was not expecting it to be. (Derek)

Derek now faced the conflict of having an ideal future possible career that was no longer connected to his present tasks. He described the curriculum as being a major factor in his choice and his feelings of being stuck in engineering:

> I really wanted to switch to chemistry about a year ago or something and I just didn't pull the trigger, I've taken a bunch more engineering

> classes that don't transfer over to that major. Some anatomy classes, things like that that aren't in that other curriculum. I was trying to do both, never taking anything that was too ... Never tried to pick a side but then last year I guess I just kind of picked one. (Derek)

Once again, the participants' coursework was impacting their perceptions of the future; in the case of Derek, the lack of flexibility in the engineering coursework caused a loss of autonomy in career choice. The present no longer connected to his future possible careers.

7.3 Discussion

Participants in this group are primarily characterized by their short extension into the future and general lack of future-oriented motivation and connectedness. The connection between the present and the future is primarily pragmatic with a focus on using their degree. These participants through some combination of these factors demonstrated discomfort with the future.

Short Extension into the Future

The short extension into the future was often accompanied by a focus on the near-future, present well-being, or the past. There seemed to be multiple possible factors related to this stunted perception of the future including a heavy workload.

> *[Classes are] not technically hard, just the amount of time that I have to put in them … is kind of keeping my full attention at the moment. Between that and studying abroad it is kind of difficult to think much further than that. (Parker)*

Previous studies have identified workload, particularly when the value of the tasks is questioned as being a major stressor and source for psychological distress for students in higher education (Deasy, Coughlan, Pironom, Jourdan, & Mannix-McNamara, 2014). Although the Deasy et. al (2014) study was conducted with non-engineering majors, studies on the culture of engineering indicate that working hard is embedded in the cultural norms of engineering (Godfrey & Parker, 2010; Stevens, Amos, Jocuns, & Garrison, 2007).

Lack of Connectedness

This heavy workload may be a contributor to the lack of connectedness for students. Students may be struggling with finding the value in the tasks they are completing, or the lack of connectedness may be caused by being overwhelmed with the present, as Parker's quote above demonstrates. Ryan also showed a discouragement from the daily grind, or repetitive nature, of college, and Amy described the stress that comes from the amount of coursework in engineering. These feelings of being overwhelmed by the present are likely due to the speed with which the participants perceive the future approaching (Husman & Lens, 1999). This future time orientation construct is

described as the perceived ability to manage upcoming events or deadlines (Hilpert et al., 2012). The deadlines in the future are perceived as rapidly approaching, causing the perceived lack of ability to manage those events.

Participants described many possible future careers as being the practical option or with little ownership of those careers beyond them being related to their degree. Derek brought up a discussion around the lack of flexibility in the curriculum in engineering. Derek also demonstrated a lack of connectedness due to perceiving his future possible careers as no longer being possible on his current career path. In fact, this is echoed by several participants facing a future *im*possible career (Pizzolato, 2007) unless they're current path changes.

> *I definitely can be an engineer. I just have to get motivated again to do it. (Ryan)*

Narrowed Perceived Instrumentality Based on Engineering Degree

Participants demonstrate a narrowed perceived instrumentality of present tasks caused by the lack of future-oriented career goals. However, they do demonstrate some perceived instrumentality of their engineering courses in a broader sense driven by the desire to use their engineering degree.

Discomfort with The Future

When participants do extend their perceptions of their future possible into the far-future, they describe a breadth of possible careers based on their degree without ownership or contingent paths connecting those careers to the present. Some participants showed discomfort with having to make a choice and some showed discomfort with not already having made a choice.

> *I am very good at generating a bunch of different paths because that's how my brain works. Picking one, oh my God. It's horrible. It's terrifying. (Selyne)*

Although these participants described discomfort with the future and narrowing the future, generally they believed that they would be able to find something they would enjoy in the future. They did not necessarily demonstrate a negative time attitude, or a negative outlook towards the future (Husman & Lens, 1999), and these participants showed general optimism for their future possibilities.

Summary

In summary, participants in the new group had a short extension into the future with a wide breadth or number of future possible careers, which they were not connecting to the present. They described being overwhelmed by or losing motivation in their present engineering coursework, which narrowed their perceived instrumentality for that coursework. Participants still demonstrated perceived instrumentality in

terms of using their current degree. When visualizing the perceptions of the future for these participants within the analogy of differently shaped cones (Figure 3.2), the shape for this group is similar to a cylinder or a cup, as is shown in Figure 7.1, with little to no narrowing of the cone shape as it extends in time from present to future. The base of the cup (the future) is wide, representing the wide variety and number of future possible careers with very little clarity or definition. The depth of the cup is shallow, representing the short extension into the future. The narrowness of the cup shows the narrowed perceived instrumentality of present tasks.

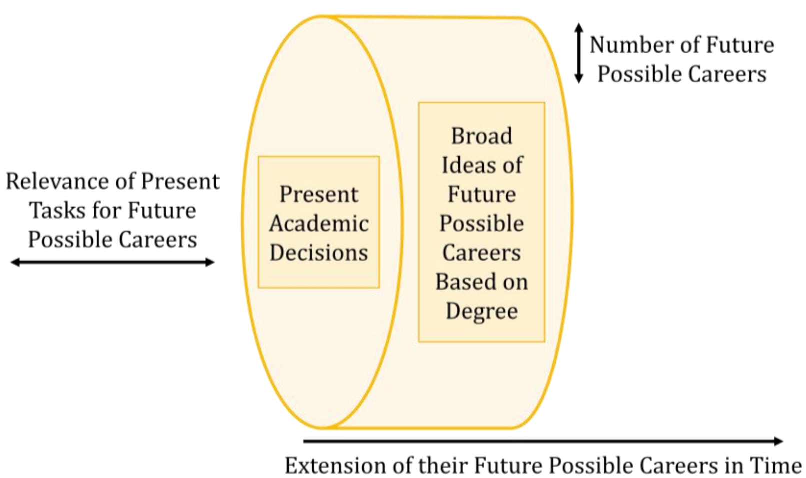

Figure 7.1 Participants Perceptions of the Future Visualized as a Cup. The depth of the cup demonstrates the short extension, the width demonstrates the many different future possible careers, and the narrowed opening demonstrates the narrowed sense of perceived instrumentality.

7.4 Implications and Next Steps

Results of this phase provided a deeper understanding of these participants ways of thinking about the future beyond their quantitative survey scores. Most notable is the lack of or limitation of future goals, making the connection between the present and

the future limited. It intuitively makes sense that this group exists and was not captured in the Exploratory QUAL Phase because of the limitations of the participant selection or that it did not exist in the target sample for that study, which was conducted at a single institution. Comparing this description to our previous qualitative findings will provide more of a context for interpreting these results. These results contribute greatly to answering the guiding research question of this study, and will be explored further in the following chapter, with a description of mixing of the data to answer the research questions.

CHAPTER 8

MIXING THE DATA

Meta-Inferences Describing the Different Ways Mid-Year Engineering Students Perceive Their Future Possible Careers

8.1 Purpose

I have described the results from each phase in the study with some description of mixing, particularly developmental mixing, where the results were used to inform the following phases of the study. In this chapter, I discuss the meta-inferences of the results from Chapters 3-7 together, focusing on key findings and how those findings complement and expand on one another to address my research questions: descriptions of students' characteristic ways of thinking about future possible careers, how those perceptions are related to current academic actions and decisions, a description of changes in those ways of thinking over time, and the distribution of

those different ways of thinking about the future across different groups of students. No new findings are introduced in this chapter, but rather the data is interpreted in the broader context of the entire doctoral study.

8.2 Characteristic Ways of Thinking About the Future

In this section, I describe how I have answered RQ1: "What are the characteristic ways mid-year engineering students are thinking about their future careers?" by combining the results of four phases (Table 2.1). Four different ways of thinking about future possible careers have been identified. In the Exploratory QUAL Phase (Chapter 3), we identified three different ways of thinking about future possible careers, visualized as different shapes of ice cream cones: Sugar, Cake, and Waffle Cones (pg. 64). The quantitative strand then allowed us to identify a fourth way of thinking about the future, described in more depth in the Explanatory QUAL Phase (Chapter 7, pg. 139).

RQ 1 is by nature a phenomenographic research question as it characterizes different ways of thinking about something. As such, the remainder of this section will focus primarily on interpreting the results of the two qualitative phases to provide outcomes similar to what we would expect from a phenomenography: a description of the individual groups, a comparison of the groups, and an explanation of how the groups fit in an outcome space (Dall'Alba & Hasselgren, 1996). Since I describe the individual groups in a previous chapter (Sugar, Cake, and Waffle Cones, pg. 64) and a

comparison of three of the groups in Chapter 3 (pg. 69), I'll first focus on comparing the fourth new group, Cup, to the previous three.

Comparing Cup to Sugar, Cake, and Waffle

Both the Cake Cone and Cup groups demonstrated a short extension into the future. Future goals described by participants in Cake Cone focused on graduation and finding a job they enjoy after graduation, similar to participants' descriptions in Cup. However, participants in Cup described thinking about graduation and finding a job they enjoy, and redirect the conversation to the near-future, such as being better prepared for class that week or finding an internship that summer so that they can learn more about their field. Participants in Cup also described finding a job that they enjoy *and that uses their degree*, narrowing their perceived instrumentality of present tasks.

Both Cake Cone and Cup groups described their future possible careers in terms of broad desired characteristics. However, participants in Cake Cone seemed to be empowered by their many opportunities while participants in Cup seemed uncomfortable with the many options within these broad perceptions of the future. The following quotes demonstrate this difference:

> I'm not trying to force a future for myself at this point. More so, be out there looking and embrace what opportunities are given to me. I used to be dead set on like what I wanted to do but I realize that's

> not necessarily going to make me happy where I want to be. (Mary, Cake Cone)

> I'm going to be working, but I don't want to plan too specifically, I guess, and have plans change or something. …I just ... I don't want to be disappointed, I don't want to have ... I don't want to go in with a preconception that's going to affect how I make my decisions and things. I don't want to say oh, I thought I was going to be here, so I'm going to say no to this. Does that make sense? (Hannah, Cup)

This discomfort and even fear of the future can be compared to participants in Waffle Cone who described some discouragement with not being able to achieve their ideal future possible career. However, participants in Waffle Cone described discouragement in a very specific context of the first job after graduation. Participants in Cup describe this discouragement more broadly.

> [Ideally, I see myself] like, working in a factory, [but realistically] I'm not expecting that to happen. (Jacob, Waffle Cone)

> My fear is that I get an engineering degree, and something happens, and I am stuck in a job that I don't really care for and that's something that I am not really...I don't ideally want in life. (Parker, Cup)

Also similar to Waffle Cone is the uncertainty beyond the first job after graduation; however, when participants in Cup described their future possible careers, it was a description of the broad possible careers related to their major, while participants in Waffle had narrowed down their future possible careers some:

> Um, I, right now if you asked me what would probably happen I would probably end up taking the position at [major automotive firm] …. I guess I can't really speak for what I'll feel like in 10 years. (Stefan, Waffle Cone)

> I don't know [where I'll be working in 10 years]. Maybe working for the government, maybe a private cybersecurity firm, maybe an insurance company if I do the actuarial science route. Honestly, I don't know. (Hannah, Cup)

Outcome Space

I described the outcome space for students' characteristic ways of thinking about future possible careers initially in Exploratory QUAL Phase (Chapter 3, pg.62). Through the proceeding phases, I began to further refine the outcome space. The key constructs distinguishing the different ways of thinking were identified (Table 4.1), and when comparing the four different ways of thinking, they are distinguished by Alignment and Clarity of Future Possible Careers (Chapter 6, pg. 110), which are not described in the shape of the cone (Figure 3.2), but rather in how the cones are

positioned in the outcome space relative to one another. The shapes of the different groups are explained in previous chapters (Sugar, pg. 65 ; Cake, pg. 68 ; Waffle, pg. 66; Cup, pg. 140). Each of the four groups are positioned in the outcome space, which is defined in terms of Alignment and Clarity of Future Possible Careers, in Figure 8.1.

Sugar Cone quantitatively has the highest Attitude and Clarity of Future Possible Career scores and is positioned in the top right corner of the outcome space. These results are supported by the qualitative data; when asked about their futures, participants described one well-defined ideal future possible career that is also attainable.

Cake Cone is situated down and to the left of Sugar Cone based on their lower quantitative scores for Alignment and Clarity of Future Possible Careers. The qualitative comparison of the Alignment of Future Possible Careers for Sugar and Cake Cone is difficult due to the very different terms in which they were discussed. The ill-defined nature of the future possible careers described by participants in Cake Cone seemed to have slightly less certainty in the alignment of their ideal and realistic future possible careers. However, both groups are positioned above Cup and Waffle Cone in terms of Alignment of Future Possible Careers.

Cup is positioned in the bottom left corner of the outcome space, with the lowest scores of Clarity and Alignment of Future Possible Careers out of the four groups. Participants in Cup described their future in very uncertain terms, with a focus on the

near-future. These participants also described feelings of being stuck in engineering, which seemed to be related to their low quantitative score in Alignment of Future Possible Careers

Participants in Waffle Cone, in contrast, described a conflicting ideal and realistic future possible career in both their interviews and their quantitative scores. Waffle Cone falls near the center of the outcome space due to their conflicting ideal and realistic future possible careers, which are more clearly defined and perceived as more attainable than those for Cup.

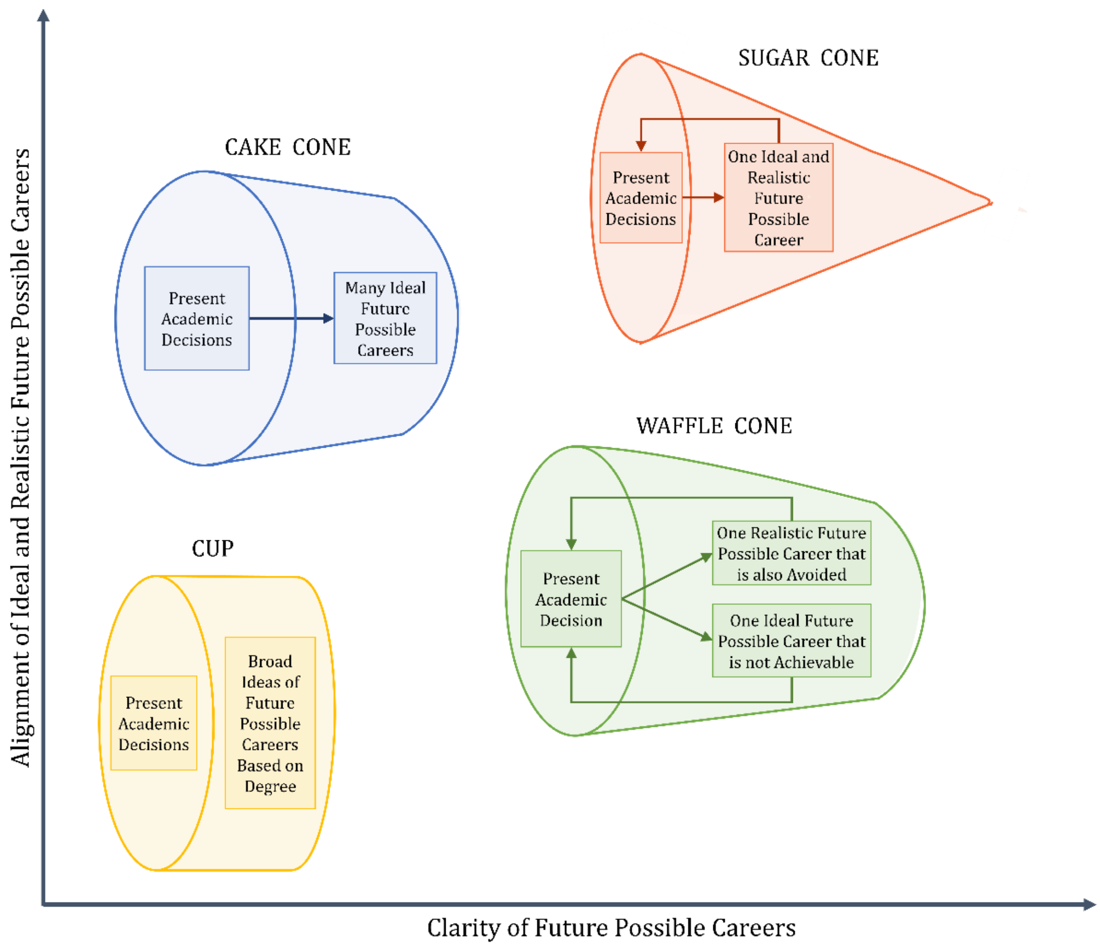

Figure 8.1 Four Different Perceptions of Future Possible Careers Represented in the Outcome Space. The shapes of Sugar Cone, Cake Cone, Waffle Cone, and Cup are placed on the axes representing the two constructs: Alignment and Clarity of Future Possible Careers.

8.3 The Connection Between Academic Actions and Future Possible Careers

Further addressing the second research question (RQ2): "How are mid-year engineering students' perceptions of their future careers related to their current academic actions and decisions?", the connections between the present and the future

for each of the four characteristic ways of thinking about the future are described using the results from each phase (Table 2.1). Participants connected their future to the present in many ways: the amount of effort they put into certain classes, the majors they chose, and the contingent goals they set such as finding an internship. There is a distinction between the perceived effect of the future on the present and the perceived usefulness of a task for future possible careers (measured as Effect of Future on Present and Endogenous Perceived Instrumentality, respectively, on the survey).

Participants in Sugar Cone described specific skills and coursework relevant to their field of interest. These participants made a distinction between engineering courses and even topics in those courses that are more relevant to their future possible career.

> I definitely do judge things based on if I think this will apply later on in life. Do I need to actually understand it? Or is it just something I need to get done, in which case I just get it done and not put as much time into trying to understand it if it doesn't click right away. So probably just like, how much effort and focus into understanding the current problem I put into and depending on if I see it applicable later on in life. (Katerina, Sugar Cone)

Rather than describing aspects of their academic work as being relevant to the future participants in Cup focused on how the academic work in the present is making it

difficult to even think about the future. While participants in Cake Cone describe every aspect of their education being relevant to their currently undefined future possible career:

> I think pretty much all of it [my education] is [relevant] because even when going down to the level of dealing with a professor, it relates to dealing with a boss. You can have a good professor or bad professor; a good boss or a bad boss. You have one that has reasonable requirements or one that has unreasonable requirements. I've had both and so that teaches you that. Learning the technical skills that we'll be using in the actual job to solve real-life problems. (Noah, Cake Cone)

These inferences are also supported by the quantitative scores for the four different factors (Table 5.6). Most notably, participants in Cake Cone responded to the Perceived Instrumentality items higher than the other clusters (5.38 out of 7). Participants in this group are the only participants to express that *anything* they are learning or doing in school is useful for their future.

Table 8.1 Connection Between Future and Present for Each Characteristic Way of Thinking About the Future

	Perception of Future Possible Careers (FPCs)	Connection Between Future and Present
Sugar	One well-defined ideal FPC deep into the future that is attainable.	Narrowed perceived instrumentality is defined by the one clearly defined FPC. The future is highly connected to the present, where the impact of the present on the future and the impact of the future on present decisions are both perceived.
Cake	Broad perceptions of the future, with an undefined attainable ideal FPC.	Broad perception of what will be useful for their present.
Cup	A lack of future-oriented motivation, with an undefined ideal FPC that is likely not attainable, or an attainable ideal FPC has not been identified.	Lack of future goals leads to a focus of the near-future. Perceived instrumentality is found through the desire to use their degree after graduation.
Waffle	An ideal FPC after graduation that is not attainable	Narrowed perceived instrumentality based on both FPC. The present

Participants in Sugar Cone responded with higher scores in the perceived Effects of the Future on the Present (5.17 out of 7). These participants described how their future career goals drove the decisions they made in the present. For example, Jeremy describes trying to network and make connections with people and companies in his field of interest, orthopedic medical device research and development. He describes setting goals, such as finding an internship to help him reach his long-term goal:

> Um, definitely I'm looking for an internship now at a medical device company that I hope to work for, um, my top list would be [Company X], um, [Company Y], kind of like in the orthopedic fields. Um, I wouldn't mind doing anything else in pharmaceuticals or cardiovascular or anything, but those are my top companies there. And then just to do research and development and then, um, I kind

> of also hope to work my way up the corporate ladder a little bit, maybe get a business background or something like that and then hopefully be able to sit, you know, in a position at one of those companies, too. (Jeremy, Sugar Cone)

Section 8.5 further demonstrates the connection of the present and perceptions of the future by demonstrating examples of how experiences in the present may facilitate a change in the perception of the future for engineering students.

8.4 Distribution of Characteristic Ways of Thinking About Future Possible Careers

The quantitative data showed significant relationships between the characteristic ways of thinking about future possible careers for two types of participants in mid-year engineering courses: seniors and those who self-identified as Asian. Owen provided some insight into the different perspective seniors may have towards the future. Our understanding of the ways of thinking about the future for the Cup group, as well as existing literature on Asian American college students and their career goals, provide some insight into why there may be a significant difference for this population.

Studies on Asian-American students in higher education have identified that these students do not always prioritize interest or other personal factors when considering career choice. Asian-American students may be focusing their choice of career goals

based on more practical factors such as financial security, prestige, and family values (Hui & Lent, 2018). There seems to be some alignment between this perception of future possible careers for Asian-Americans and for participants in Cup. Participants in Cup described very practical characteristics for their desired career characteristics. Participants also described the family pressure to remain in engineering in a way that did not come up in the Exploratory QUAL Phase.

There is ample research on the many distinct cultures that fall under the label of "Asian"; however, we do not have data from the interviews or survey on how participants identify themselves within that label of Asian culture. The findings of the Exploratory QUAN Phase and the Explanatory QUAL Phase both provide evidence further supporting the existing literature on Asian-American college students and the characteristics of their career goals, and indicate the need to include a discussion of cultural effects in future quantitative and qualitative work.

There also may be some variables related to the clusters that we are not capturing in the survey demographic questions. Many of the participants described unique circumstances influencing their academics. One participant described returning to college after working and being in the military. He discussed the struggles he encountered in being older and having different life experiences than his classmates.

> For me, all the group setting stuff has just been super awkward. I don't want to overstep my boundaries 'cause I'm talking to people

> that are at a more impressionable age of their ... You know what I mean? (Derek, Cup)

> Some of the time, extra time I had to spend doing the group stuff because it was like ... I got flaked out on so much. They're 18, it is really important, if one is on the track team okay. It is really important for them to go to the track banquet, you know and to get a new outfit for the track banquet, I get it. It would have been important to me when I was their age, too. (Derek, Cup)

Derek also went on to describe how his age affected the career paths he chose, where fields that require longer time in school were less appealing than those attainable with a bachelor's degree.

> But then again, you're looking at for me, back to school when I was 29 I think, and so it's like I guess I've heard that the chemistry route is going to require a lot more school to actually work in the field, like maybe 10 years of school. Eight, 10 years of school to actually be in the field whereas if you get an engineering degree you can go to work in the field after you get your Bachelors. (Derek, Cup)

> I'd love to do something like that, but I don't know if I'm the kind of person they're looking for to do that, because I'm older and then

> there's the pressure, you know, just like financial pressure. (Derek, Cup)

Another participant, Parker, described his non-traditional family situation growing up and how that has influenced his perception of the importance of focusing on the present to gain a variety of experiences:

> To my future, most importantly, I think it's [traveling is] going to be beneficial to me as a person. I was born in [birth state] and then I moved here to [university state] and I haven't left since...because [of my non-traditional family situation]. So, I have just been kind of here in [university state] for twelve years now. <u>I think my thing is broadening the horizons means moving and traveling and meeting new people.</u> The more you know about people as a whole, I think you can better understand what they need. <u>I think that is important as an engineer because we need to know, what people need and what they want</u>. (Parker, Cup)

Parker also described how his experiences having a childhood in a non-traditional family situation have driven his future goals:

> When I was younger I didn't want to do anything. I didn't... <u>I felt like I was not somebody that could help anybody or teach anybody or help anybody</u>. I think that was where they [new family] tried to teach

> me that I just need to reach up and if I can grab it then I can grab it. If not, that is okay I will grab something else that is useful. (Parker, Cup)

This recent encouragement has led Parker to set goals based on other people's expectations: "I think others have high expectations and I push myself to those instead of what I should be doing." These experiences have also fueled his desire to help others and be a mentor to others. These examples of returning military and non-traditional family situations, as well as the family pressures and balancing between two different fields described in Chapter 7 (pg. 121), are unique situations that did not come up in previous interviews. These are all variables affecting perceptions of future possible careers that were not measured in the quantitative strands, but that the qualitative strands allowed us to understand.

8.5 Shifts in Ways of Thinking Over Time

The shifts in ways of thinking over time was primarily addressed by the longitudinal data across one academic year in the Follow-Up QUAN Phase. Some indications of how these perceptions shift over time were also described by participants in the Explanatory QUAL Phase.

Academic Experiences Facilitating Shifts

The survey results for Owen (who was removed from analysis in Chapter 7)in Distribution 2 indicated that he fit into the Cup group. However, his interview

responses were not matching with what I would expect from the quantitative scores for the Cup group. He demonstrated having a clear idea of his first job after graduation in his interview:

> Yeah. For me, [my first job after graduation will] probably be start out working for a general contractor as a field engineer. That would be a job that would require long hours, 60, 80-hour weeks, some. Then, slowly work my way up, promotion at a time, get into a higher role as assistant project manager, project manager, which would then reduce my hours into a more reasonable 40-hour work week, which I know would be easier to more balance out life with a family plus work. Then, hopefully look into buying a home, everything, once I get my career established. (Owen, Senior)

Although he knew that he wouldn't be able to achieve his ideal future possible career immediately after graduation, he did think that he would be able to achieve it:

> My ideal future job would probably be an executive project manager or something at a company, or at a smaller company, be like a branch manager and have entire staff under me of project managers, estimating for a medium sized general contractor. (Owen, Senior)

Both the well-defined descriptions of the future and his comfort with discussing his goals for the future are inconsistent with what I was seeing in the qualitative data for

participants in Cup. He goes on to explain this difference during the survey validation interview prompts:

> Yeah [I think my perceptions of the future are clearer now], 'cause I think this [survey] was right before we had our career fair. So then I had talked to a couple companies there that all of them generally have pretty similar things, all the companies I had talked to. So I felt pretty solid on where I would be going based off those. (Owen, Senior)

Owen demonstrated how experiences and context can impact participants' perceptions of future possible careers. Owen was graduating in less than a year, making the extension of the first job after graduation closer to the near-future. At the time he took the survey, he had a broad idea of his future possible careers without a clear understanding of how he would achieve that possible career:

> Because I think when I filled this [survey] out, I just hadn't really looked into position titles and everything. I knew where I wanted to go, but I didn't know where I would start to get there. (Owen, Senior)

With this first job after graduation rapidly approaching, there was a level of discomfort with the unknown aspects of his future possible careers, particularly prior to the career fair. For Owen, the career fair provided the opportunities for defining his options for a first job after graduation, the steps needed to attain that job (such as

interviews) and helped him find a realistic way to achieve his ideal future possible career.

In contrast, Amy, a junior in EE, also attended the same career fair. She explained that the career fair didn't change her perception of the future; rather it helped her better understand the range of jobs available for her degree. When asked if she believed that the career fair influenced her thoughts about the future, she responded, "Not really," and went on to describe how it helped her better understand the different options in EE and characteristics of those careers that are desired:

> Yeah, like it let me see like what kind of companies I would probably want to be with and which ones I don't. (Amy, Cup)

The same experience, a career fair, had a different effect on Amy and Owen's perceptions of the future, likely due to their year in school.

Reflection through Surveys and Interviews Facilitating Shifts

Different academic experiences, such as a career fair, are designed to facilitate changes and refinement of perceptions of future possible careers. However, shifts in those perceptions can also be unintentionally changed through the act of participating in a research study. Grace explicitly described how taking the survey for this study helped her realize how her two future possible careers can align.

> Catherine: Yeah? We expect, you know, these things change over time, and I get that. I wanted to check for 'the career path I would

find most rewarding is not realistic for me.' You had answered a five and just now you said one [strongly disagree], so that's kind of a big shift. Do you feel like that changed over time or were you thinking of something different when you read it?

Grace: I feel like it's partly changed, and I also think the way I thought about the question changed because I think when I was answering that question I think I was thinking if it's really realistic for ... I think I was thinking of my career as like of engineering and dance being really connected. I think that I said five just because I'm not sure exactly how realistic that would be. But then I think at the moment I think it is realistic that I can ... even if it's not engineering and dance connected into one job, I think it's realistic that I can make my career what I want it to be in both. (Grace, Cup)

Grace also described a recent shift in her relationship with dance, realizing it was important for her to keep dance as part of her life and career after school. This realization occurred between taking the survey and being interviewed.

Her recent changes in her perceptions of her future possible careers may explain why Grace could describe a well-defined goal path deep into the future yet was uncomfortable with the vagueness of that path. It is likely that this path was one she had only recently started thinking about, and the discomfort came from not having

spent much time thinking it through. She seemed to be transitioning into a more aligned and clear perception of the future.

Better Understanding of Shifts Over One Academic Year

In Chapter 6, The Follow-Up quan Phase, participants' shifts in perceptions of future possible careers over one to two semesters were described quantitatively. Our understanding of the new cluster, Cup, was deepened in the Explanatory QUAL Phase (Chapter 7, pg. 136), and we can reassess the interpretation of the longitudinal survey data.

The survey scores for the participants who were interviewed in the Explanatory QUAL are shown in Table 8.2. Note that Derek was removed from the cluster analysis in Distribution 1 due to having skipped an item.

Table 8.2 Survey Scores for (Cup) Interview Participants

	Distribution 1				Distribution 2			
	kCL	kAL	kPF	Cluster	kCL	kAL	kPF	Cluster
Parker	5.4	5.17	6.25	Sugar	3.60	5.16	5.75	Cup
Hannah	5.8	6.00	6.75	Sugar	3.40	5.16	5.50	Cup
Selyne	2	2.83	5	Cup	4.00	5.00	6.25	Cup
Ryan	3.2	3.33	4.25	Cup	2.20	3.33	3.25	Cup
Grace	2.6	5.50	5.75	Cake	3.00	4.50	5.75	Cup
Amy	3.6	4.83	6.75	Cake	3.8	4.5	6.5	Cup
Bill	2.8	5.17	6.00	Cake	2.60	3.33	6.75	Cup
Derek	3.20	3.33	3.75	NA	2.60	2.33	2.50	Cup
Owen	3.20	4.83	4.50	Cake	4.00	5.00	4.50	Cup

Although appropriate for participant selection, when looking at Table 8.2, we can see that the binning method for identifying clusters in Distribution 2 is not consistent with the more reliable clustering methods. Also, in *Table 8.2* we can see that the interview participants experienced a wide range of shifts from Sugar, Cup, and Cake.

From the longitudinal quantitative data from Chapter 6 (pg. 115), one of the most significant "shifts" from Distribution 1 to 2 was that 47% of participants who were in the Cup group in Distribution 1 were also in the Cup group in Distribution 2. For our qualitative understanding of Cup, it seems that these participants were starting with an unclear idea of the future and were not clarifying their future over time. Because of the timing of the survey distributions (about the second month of the semester), it is also possible that these participants were feeling overwhelmed at the time of the survey and unable to think about the far-future. Derek and Ryan, whose quantitative scores were low for both Distribution 1 and Distribution 2, described their current state of thinking about the future as being a new and temporary state, with comments shifting to their past perceptions being better defined and more optimistic.

> So, yeah. Usually, if you asked me that question last semester, it would have been 100%, oh, yeah, my future goals are to graduate, so I want to work hard, and enjoy it while I'm doing it. But right now, it's kinda like, I want to work hard, but it's just not fun. So I'm not doing as well as I should. (Ryan, Cup)

Although, generally, it seems that these feelings of being stuck in engineering as described in the Explanatory QUAL Phase (pg. 121) are echoed in the trends in the quantitative longitudinal data (Figure 8.2).

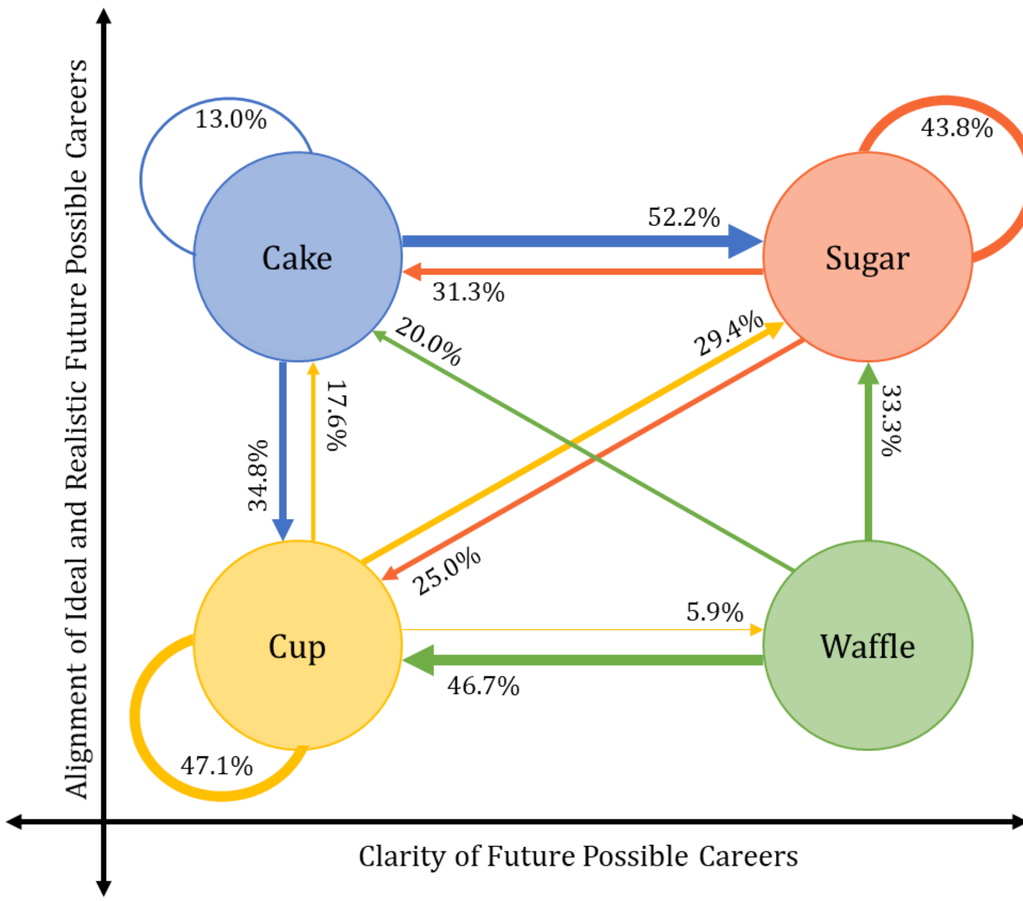

Figure 8.2 Shifts of Characteristic Ways of Thinking About the Future Over One Academic Year. Each circle represents one of the four characteristic ways of thinking about the future. Arrows of the same color leaving the circle represents the participants who shifted out of that state in Distribution 2. The thickness of the arrows is proportional to the percentage of participants who shifted out of that state.

8.6 Summary

In this chapter, the meta-inferences from the data from each phase of this doctoral work (Chapters 3 – 7) have been discussed. The following chapter concludes this dissertation with a summary of the key findings, limitations, implications, and future directions.

CHAPTER 9

CONCLUSIONS

Conclusions, Implications, and Future Work

9.1 Summary of Key Findings

The discussion in Chapter 8 described the key findings as meta-inferences from all phases of this doctoral study. For an explicit breakdown of how each of the four sub-research questions were addressed, follow the headings and discussions in Chapter 8 (RQ1 pg. 143; RQ2 pg. 149; RQ3 pg. 153; RQ4 pg. **Error! Bookmark not defined.**). This chapter describes more holistically the answer to the guiding research question: "In what ways are mid-year engineering students thinking about their future careers, and how are their perceptions related to their current academic actions and decisions?"

Sugar Cone: Clear and Aligned

Students describing having a matching ideal and realistic future possible career and perceptions that extend deep into the future, well beyond graduation were characterized as the Sugar Cone group. These students also demonstrated a narrowed perceived instrumentality of current tasks; they value tasks primarily on how well that task will help them in achieving their specific career goal. This way of thinking about the future is described as having a clear and aligned ideal and realistic future possible career. Mid-year engineering students seem to shift towards this clear and aligned way of thinking about future possible careers and tend to maintain this way of thinking once it is reached.

Waffle Cone: Clear and Unaligned

Participants in the Waffle Cone group described conflicting ideal and realistic future possible careers which extend to their first jobs after graduation. These students have a narrowed perceived instrumentality based on tasks related to either their ideal or realistic careers. Participants seem to resolve their clear but unaligned perceptions of future possible careers over time.

Cake Cone: Unclear and Aligned

Students who described their future possible careers using very broad characteristics without defining future goals beyond graduation were characterized as the Cake Cone group. These students described wanting to gain a breadth of knowledge and skills, prompting an endogenous perceived instrumentality across most of their courses.

These students also tended to gain more clarity of their future possible careers over time and shift towards a more clear and aligned way of thinking.

Cup: Unclear and Unaligned

Students characterized as being in the Cup group described goals for the immediate future without discussing future-oriented goals. These students described the reasons for their short extension into the future as not wanting to set goals for fear of being disappointed or feeling “stuck” in engineering, which quantitatively is described as unclear and unaligned perceptions of ideal and realistic future possible careers. This feeling of being stuck seems to be echoed in the longitudinal analysis, which showed that nearly half of the participants in Cup tend to remain there over time. Across all participants, this is the least common way of thinking about the future; however, of the participants who identified as Asian, a significantly greater proportion were in Cup (33% compared to 19%).

9.2 Limitations

In general, a mixed methods and pragmatic approach to research provides advantages for holistically answering the research question and understanding the social reality. However, some limitations arose in this study around data collection, analysis, and the inferences that can be made from mixing.

The underlying assumptions of phenomenography rely heavily on context. The context in this study was defined as mid-year engineering coursework in large

engineering classes. However, due to the multi-phase design, data collection occurred over three years. Unexpected political and economic shifts occurred in that time period, which influenced the perceptions of participants. The direct comparison between the two qualitative phases, Exploratory and Explanatory QUAL Phases, may be biased by the changes in the context over time. Because we have quantitatively captured the four distinct ways of thinking about the future at one time-point in the Exploratory QUAN Phase, we can assert that there are at least four ways of thinking about the future and reasonably use the qualitative data to better understand those ways of thinking about the future—answering the phenomenographic nature of the guiding research question. This concern is characterized by sample integration legitimization, that the way the data was sampled influences the meta-inferences that were drawn from the data. The underlying philosophies and the phenomenographic nature of the research question drove the need for participant selection. The changes in political climate over the three years do not invalidate the participants' perceptions, and provide significant results.

The need for participant selection drove the Follow-Up quan Phase, and the analysis used to bin participants into one of the four clusters was appropriate for quickly identifying participants who fit minimum score requirements. However, when looking at a longitudinal quantitative analysis, the methods used in Distribution 2 provided inconsistent results with the scores and clusters in Distribution 1. The qualitative data helped us to better understand these shifts. Although the descriptive

statistics would change with alterations to the "binning" criteria, the general trends remained and are supported by the qualitative work.

The time between the survey completion and the interviews was as short as practicality would allow. However, we did see some change in perceptions of thinking about the future. The timing of the survey was chosen to capture students' experiences near the middle of the semester. In the future, checking for conflicts that may not appear on an academic calendar would be appropriate. The career fair at one institution between the survey and interviews influenced participants' perceptions of the future. Including survey validation prompts allowed us some insight into these changes, and a discussion of the results took these changes into account.

There were some sensitive discussions about participants' personal lives and well-being that were not anticipated based on past interviews. I have had some training in how to handle disclosure of concerning personal information at my own institution. However, in the future, being prepared with how to handle those discussions at the institution the students are enrolled in would be beneficial. Thankfully, participants in this study showed no indication that they would harm themselves or others and indicated a support system around the topics they brought up.

In the last phase, the need for interviewing participants within a certain time period drove the practical need for collecting data through multiple sources, in-person and via video-chat. Aspects of the interviews were kept as consistent as possible, with the

interview protocol, the presence of me as a the primarily interviewer and a second interviewer. Although I asked participants to meet in a quiet and private location with good internet access, some participants still met in a public location with or did not have a reliable internet connection. Bad connections and background noise caused some interruptions in completing these interviews.

When considering all 30 interview participants together, 21 of those participants came from one institution. Because of the need for restricting the context to a reasonable size for data collection to reach saturation within that group of participants, the context was restricted to one institution. For these same reasons, BME and ME also make up most of the interview participants. Again, one of the strengths of mixed methods research is weakness minimization. What would be a weakness in qualitative research is minimized with the inclusion of the quantitative strands. Although many of the qualitative examples and quotes are driven by BME or ME careers, the quantitative results are descriptive of the students in sophomore-level CE, EE, and ME courses. The qualitative data provide insights into those quantitative results.

9.3 Implications

These findings have implications for engineering educators, researchers, and policy-makers. I discuss here the implications of the doctoral study in terms of intellectual merit, or how the results advance the knowledge of the field of engineering education, and broader impacts, or the potential benefits to society.

Intellectual Merit

Most notably, this work advances the knowledge of the field of engineering education by presenting a framework for describing mid-year engineering students' perceptions of their future-possible careers and how those relate to their current academic actions and decisions in terms of the different constructs in future time perspectives, future possible selves, and goal paths. Constructs from each of these frameworks, such as speed, perceived instrumentality, contingent goal paths, and ideal and realistic future possible careers, are all used to describe and distinguish four characteristic ways of thinking about future possible careers.

This work also advances our understanding of future possible selves in terms of careers by defining future possible *careers* as an aspect of one's future possible selves related to the cognitive manifestations of self in a career. Future possible careers is an important consideration in future-oriented motivation for engineering students, as shown by this work.

The results of this work also contribute to existing literature on Asian-American career goals. This work expands on the existing literature by providing an understanding of how the previously identified aspects of Asian culture, contribute to how participants who identified as Asian in this study describe their future possible careers in comparison to other demographics. This work also contributes to how we consider demographics, and if we should be collecting demographic

information distinguishing the many different cultures within that category of "Asian."

Another advancement for research in engineering education is the refinement of a survey instrument to quantitatively measure the characteristically different ways of thinking about the future. This survey instrument can be used in future research or to further improve the research-to-practice cycle. The results from the survey instrument are useful for describing the motivations of students in an instructors classroom, which would help instructors consider many motivations when creating an inclusive classroom environment.

Research-To-Practice

In this work, I have demonstrated and provided an example for disseminating results directly to practitioners as an integrated part of the methods. As part of the incentive for instructors to distribute the survey to their course, I offered a summary sheet with the results specific to their course (Appendix O). The summary sheets provided some insight to instructors of the motivations of the students in their large-enrollment courses. By returning these summary sheets to the instructors, I have improved the research-to-practice cycle. Also, to improve the research-to-practice cycle, I have presented the results in a visually impactful and memorable way that prompts discussion for practitioners.

Research Methodologies

This doctoral study has presented several methods which contribute to the engineering education research community's understanding of how to use mixed methods and phenomenography to answer a research question. I have presented a multi-phase mixed methods design, the design which has some of the most pragmatic potential, but also has "received less attention." (Creamer, 2018, p. 206). This study can be used as an example for the pragmatic advantages for using a multi-phase design to expand inferences beyond either the quantitative or qualitative strand of data.

Also, using a mixed methods approach to phenomenography has allowed us to identify the different ways of experiencing the phenomenon within the broader population of mid-year engineering students. There are some issues with combining phenomenography with quantitative methods, mainly the contextual issues addressed in the limitations section (pg. 168); however, the strengths of using mixed methods are apparent in the findings of this study. By using phenomenographic approach in a multi-phase mixed methods study, we were able to identify a fourth group not identified in the initial phenomenographic study which was limited by context to a single institution and two majors.

Broader Impacts

This work has demonstrated how mid-year engineering students' goals for the future and present academic experiences are connected. As practitioners and policy-makers,

we can continue to provide opportunities for students to develop their perceptions of their future possible careers, such as career fairs or through reflection. For example, as instructors, we can prompt students to reflect on how their goals for a course connect to their long-term goals (Appendix P). One of the easiest ways practitioners can reduce unnecessary workload for students is by communicating with one another to coordinate due dates for large assignments or exams. Simply acknowledging students' time and workload demonstrates to students that practitioners are considering the students' needs.

In future-oriented motivation literature, an important way to motivate students in the classroom is to connect the present to the future and show the relevance of the material being covered in class (Oyserman, 2015). However, many of the techniques that have been discussed in the literature, such as speaking about the future in terms that make it seem nearer and more important, could contribute to the factors affecting participants in Cup. Participants in Cup already experience feelings of being overwhelmed even by the near-future and bringing the far-future to their attention may only cause additional distress and lack of motivation. In future directions, we will assess how engineering programs can consider all of these different ways of thinking to create an inclusive and supportive environment for all types of student motivations and perceptions of the future.

Further, this research has also prompted a discussion for how we are considering the students in our policy decisions. It is important to consider how the flexibility of

engineering curriculum or the course load for those crucial middle years for engineering students impacts students' motivations. By allowing for some flexibility in engineering curriculum, we would be providing a safe opportunity for students to find the career path that is the best fit for their future goals, and hopefully reducing the fear, discomfort, or feelings of being stuck associated with thinking about the future. When considering inclusivity in our course or policy decisions, we can also consider different motivations and perceptions of the future.

9.4 Future Directions

The results of this study bring to light questions beyond the scope of this doctoral work. Future work could consider the impact coursework has on perceptions of the future, the relationship between the past, present, and future, how these perceptions change over time, and how to create inclusive engineering cultures to support these different ways of thinking about the future.

Because of the impact of coursework on perceptions of the future, it may be interesting to explore a replication study, for example conducting a phenomenography in the context of an engineering program implementing revolutionary changes to engineering curriculum. Also, a replication study would forward this phenomenographic exploration by potentially qualitatively capturing the four different ways of thinking about future possible careers at one time point. We would be able to make more effective comparisons across all four groups without the potential influences of changes in political and economic factors.

Along with the importance of coursework on student motivation, the data in this study demonstrates the importance of considering the past. The past, present, are clearly interconnected, and as demonstrated in the most recent interviews, students' present actions and perceptions of the future are often difficult to describe without the context of the past. A study exploring this connection between the past, present and future in more depth may provide some interesting insights into these characteristic ways of thinking about future possible careers.

The results of this study provided some interesting insight into how these characteristic ways of thinking shift over time and what factors may facilitate change, future work could explore these changes in more depth. A longitudinal study could be conducted quantitatively capturing these different ways of thinking about the future for the same participants over time, with additional interviews intended to capture the changes in perceptions of the future and why students perceive those changes to be taking place. Quantitative methods for capturing these different ways of thinking about future possible careers would need to be improved. The results of this study will help inform future studies in refining a survey instrument and methods for identifying the characteristic ways of thinking about future possible careers.

Finally, now that these different ways of thinking about the future have been identified, and implications of those ways of thinking about the future have been explored, the question remains of how mid-year engineering students can be best supported in their engineering programs. Exploring the engineering culture in

different programs could help further the results of this doctoral work for how to create an engineering culture that is more inclusive to different types of perceptions of the future and motivations. A future study could explore the culture of engineering programs and what aspects of those programs best support engineering students' motivations and well-being.

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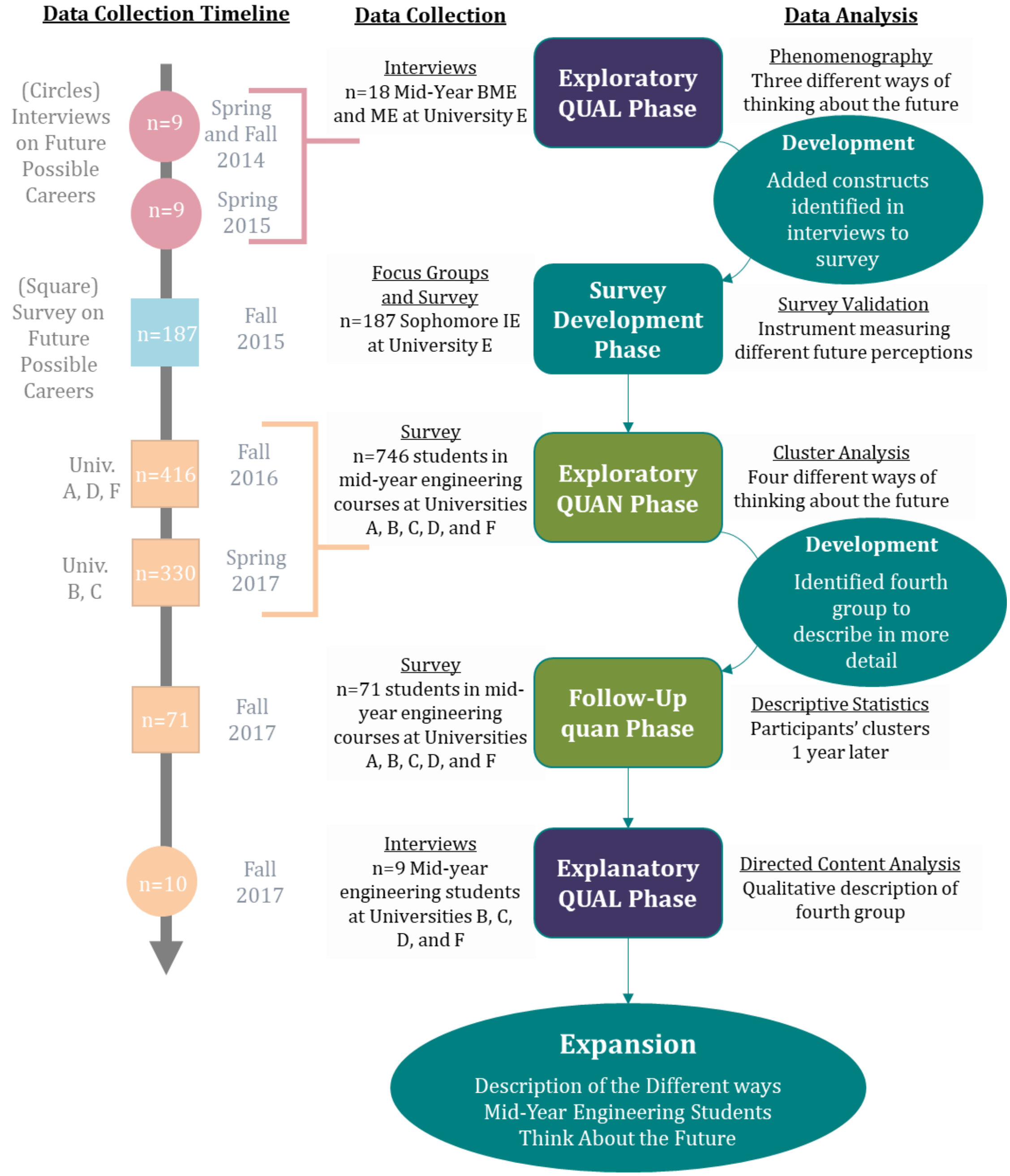
Appendixes

List of Appendixes

Appendix A Research Design Diagram

The Data Collection Timeline, faded on the right, shows the type of data, number of participants, and data of data collection for each phase of the doctoral study. On the right is the research methodology timeline where the boxes show phases of the study. To the left and right of the boxes are the data collection and data analysis description for that phase. The circles show the stages and type of mixing that occurred.



Appendix B Description of Participating Universities

Participants in this doctoral study were attending one of six universities (univ), given the pseudonym A-F. The population, research level, undergraduate enrollment, size, and selectivity is listed in the table below. Each of the institutions are 4-year or above, public, doctoral universities. All classifications are based on the Carnegie Classification of Institutions of Higher Education.

Univ.	Population	Research Activity	Enrollment Profile	Size	Undergraduate Profile
A	58322	Highest Research Activity	High Undergraduate	Large	More Selective
B	43625	Highest Research Activity	Majority Undergraduate	Large	More Selective
C	33989	Highest Research Activity	High Undergraduate	Large	More Selective
D	25962	Higher Research Activity	High Undergraduate	Large	More Selective
E	21857	Highest Research Activity	High Undergraduate	Large	More Selective
F	11225	Moderate Research Activity	High Undergraduate	Medium	Selective

Appendix C Description of Participants in Qualitative Strands

Thirty participants were interviewed in this doctoral study, their pseudonym, major, institution, semester interviewed, and phase their data were analyzed. Majors include biomedical (BME), cyber (CYE), electrical (EE), industrial (IE), mechanical (ME), mechanical and aerospace (MAE), and textiles (TE) engineering.

Phase	Name	Major	Institution	Year	Interview
Exploratory QUAL	Caroline	ME	E	Sophomore	Spring 2014
	Damon	ME	E	Sophomore	Spring 2014
	Katerina	BME	E	Sophomore	Spring 2014
	Katherine	BME	E	Sophomore	Spring 2014
	Stefan	ME	E	Sophomore	Spring 2014
	Bonnie	BME	E	Junior	Fall 2014
	Jeremy	BME	E	Junior	Fall 2014
	Matt	BME	E	Junior	Fall 2014
	Silas	BME	E	Junior	Fall 2014
	Anna	BME	E	Sophomore	Spring 2015
	Chris	ME	E	Sophomore	Spring 2015
	David	BME	E	Sophomore	Spring 2015
	Emily	ME	E	Sophomore	Spring 2015
	Jacob	ME	E	Sophomore	Spring 2015
	Logan	BME	E	Sophomore	Spring 2015
	Mary	ME	E	Sophomore	Spring 2015
	Noah	ME	E	Sophomore	Spring 2015
	Will	BME	E	Sophomore	Spring 2015
Survey Development	Helen	IE	E	Sophomore	Fall 2015
	Nikki	BME	E	Sophomore	Fall 2015
	Thomas	IE	E	Sophomore	Spring 2015
Explanatory QUAL	Amy	EE	C	Junior	Fall 2017
	Bill	ME	C	Junior	Fall 2017
	Owen	CNE	C	Senior	Fall 2017
	Ryan	TE	C	Junior	Fall 2017
	Selyne	EE	B	Junior	Fall 2017
	Grace	EE and Dance	B	Junior	Fall 2017
	Hannah	CYE	F	Junior	Fall 2017
	Derek	BME	F	Sophomore	Fall 2017
	Parker	MAE	D	Sophomore	Fall 2017

Appendix D Exploratory QUAL Interview Protocol

<u>Long Term Goals</u>

What are your goals for the future?

What are your personal goals for the future?
What are your career goals for the future?
Describe where you see yourself in 10 years?
Can you think of anything that could make you change your goals?

What would you <u>ideally</u> like to be in the future?

If you could pick one thing and it could happen what would it be?
If you could pick a professional goal to attain what would it be?

What do you think you can be in the future?

What are you actively striving for?
What goals are you currently pursuing to reach this future?

What do you not want to be in the future?

In other words, what jobs, or careers do you know you do not want to pursue?

Why are you pursuing an engineering degree?

What parts of your education do you see as relevant to your future?

What skills are relevant to ideal self (who you would ideally like to be)?
What skills are relevant to who you think you could be?
How do you see your education playing into your career?

What skills do you view as important for your profession?

What kind of profession (if more than one profession mentioned)?

Appendix E Complete Qualitative Code Book

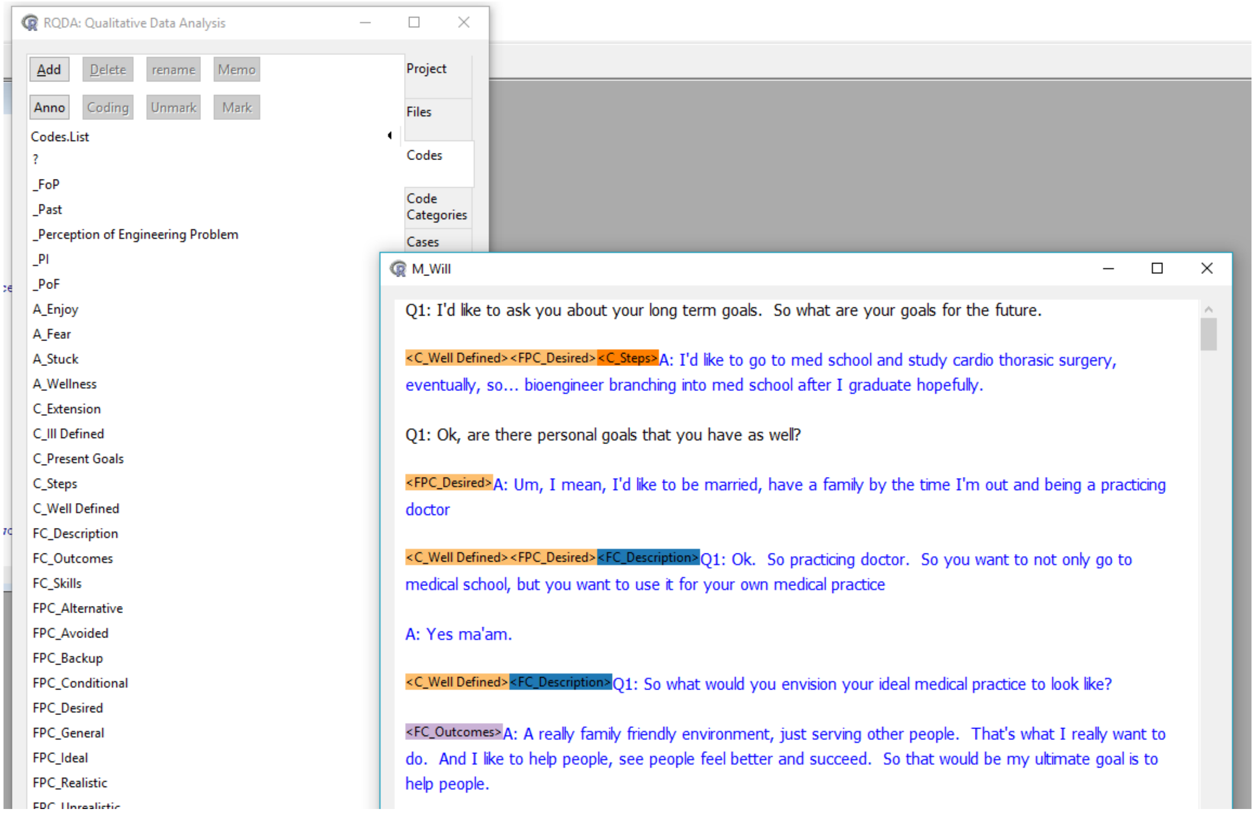
Category	Code	Name	Definition	Example
Affective (A)	Enjoy	Expression of Enjoyment	The student expresses any type of enjoyment, including wanting to enjoy their career in the future	"Long term, I would have to say [my goal is] to just finding a job that I would actually enjoy in engineering." -Parker
	Fear	Expression of Fear	The student expresses any type of fear, including fear influencing what they are doing now or fear of a future.	"Picking one [future career], oh my God. It's horrible. It's terrifying." -Selyne
	Stuck	Feelings of Being Stuck	The student expresses feeling stuck in the present or in terms of their future.	"[I] wanted to switch majors for a long time, but now I feel like I've got too far into it to … switch…yea." -Derek
	Wellness	Focus on Wellness	The student describes wanting to focus on well-being, mental health, or wellness.	"Some people try to call that selfish, but I think that it's better for mental health and mind. I don't want to wake up and just dread going somewhere for the rest of my life."
Future Possible Careers (FPC)	Alternative	Alternative Future Possible Career	The student describes a future that could have been possible in the past.	"It used to be get done with school and move away from here. Now it's just get done with school and then take it from there."
	Avoided	Avoided Future Possible Career	The student describes what they do not want to be in the future.	"An automotive engineer. I don't not want to go into automotive. It just doesn't interest me. "
	Conditional	Conditional Future Possible Career	The student describes the future using a conditional statement--a future that is not necessarily possible given their current behavior.	"I definitely can be an engineer. I just have to get motivated again to do it." -Ryan
	Desired	Desired Future Possible Career	The student describes what they	"[I want] to be in an environment where...I

			do want to be in the future.	always have that opportunity to learn."
	Ideal	Ideal Future Possible Career	The student describes what they ideally want to do in the future.	"Honestly, my ideal future would be being able to travel without restraint and not having to worry about working."
	Backup	Backup Future Possible Career	The student describes having future possible careers that they will pursue if their realistic future possible career fails.	"Because I want to do engineering, but if engineering doesn't work out, then I think I might switch to Physics."
	General	General Future Possible Career	The student lists options for jobs based on their major, without making a judgement of the job or identifying it.	"I know there's like three categories. There's research and development, I guess like design, and something else." -Amy
	Realistic	Realistic Future Possible Career	The student describes what they can realistically do in the future.	"Probably realistically, if I didn't get up to being a pilot, then working at a company like Boeing"
Clarity (C)	Well Defined	Well-Defined Future	Having a defined future goal that one wants to attain. The goal should be clearly defined by the student.	"I really see myself in the bioengineering field doing R&D for a company, orthopedics, possibly implants, whatever they have to offer, and I could get excited about."
	Ill Defined	Ill-Defined Future	The student describes a future goal using ambiguous terms. The goal is not clearly defined by the student.	"What do you mean? I mean, manufacturing, but that's about as much ... I mean, I hadn't really thought of something very specific."
	Extension	Deep Extension of Future Goals	The student describes future goals deep in the future.	"And in the far future, I guess, graduate college, with a good GPA, get a job, all that good stuff. And still be enjoying the process."
	Present Goals	Goals in the Present	The student describes goals for the present or very near future (i.e. tomorrow)	"I guess, for the near future, get back to my good study habits, because lately I've been feeling a lack of motivation." -Ryan

	Steps	Steps to Reach Future Goals	The student describes a series of steps or paths needed to reach a distant future goal.	"I'd like to go to med school and study cardio thoracic surgery, eventually, so... bioengineer branching into med school after I graduate hopefully."
Future Career Descriptions (FC)	Description	Description of Future Career	The student describes attributes or characteristics of their future career.	"But like, yeah job-wise, something where I feel like I'm doing something every day, I'm not just sitting at a desk."
	Outcomes	Outcomes of Future Career	The student describes outcomes of their future career.	"So that would be my ultimate goal is to help people."
	Skills	Skills Needed for Future Career	The student describes skills needed for their future possible careers.	"I guess getting a lot of experience working with people and working on teams of people is really important. Those are some skills I need to build."
Present (_)	FoP	Effects of Future on Present	The student describes how their future goals are influencing what they do in the present.	"As far as keeping my grades up so that my applications look good and also just understanding the material as opposed to just memorizing it so that I know when I'm in a job, I won't be stuck or look bad."
	Past	Past Experiences and Perceptions	The student describes an experience that occurred in the past or a perception of the present or future that was formed in the past.	"Yes, that also because to begin with engineering wasn't my first choice as a profession. I was set on being a teacher. I just didn't want to even be a professor, I just wanted to help kids and students help figure out who they were"
	PI	Perceived Instrumentality	The student describes how relevant they view certain tasks.	"I'll be able to properly configure my machines, my inventions so that they work as I want them to, and without Statics and Dynamics, I would not be able to even come close to that."
	PoF	Past/Present Actions	The student describes how what	"I think this summer I'm going to do an internship

		Influence on Future	they do in the present influences what they will do in the future or what their future goals are.	to figure out if I'm actually interested in industry or if I should stick with research."
	Engineering Problems	Perceptions of Engineering Problems	The student describes their perceptions of engineering problems.	"I think most problems can be approached in like through an engineering way."

Appendix F Example of Qualitative Coding in RQDA



Appendix G Example Memos from Interviews

Below are scanned copies of my pre- and post- interview memos. Any identifying information (demographics, institution, names, etc.) are whited out. The three examples are chosen from the middle of the interviews I conducted in the Explanatory QUAL Phase.

Ryan

10/10/2017
1:30

71. Pre-Interview Memo

I just had a lunch break and watched an episode of the flash. I was feeling run down, but it feels like the adrenalin has kicked in.

I need to send out reminder emails / prepare for tomorrows interviews so I feel a little distracted.

I got an email from him that he's out of class, grabbing something to eat, the coming. I like the update. It's thoughtfull and shows respect.

I know he is a junior in Textile Engineering at . He identifies as . He had some of the lower survey scores, so I am excited about this interview.

is my second interviewer. I haven't heard from her yet. There's still 20 min. I am a little nervous b/c I haven't chatted with her before, and I want to make sure it's working, and I think he may be early.

RYAN

10/10/2017

71 Post Interview Memo

That interview was emotionally difficult. He seem defeated and I wasn't sure how to ask questions. It seemed like my questions were adding to his own internal struggles.

I think these were the kinds of responses I was expecting from this group.

I feel like he definitely does not fit with cake sugar or waffle.

GRACE 10/11/2017 10:30

18 Pre-Interview Memo

This is my first Skype interview. I'm nervous because it seems like a lot more can go wrong.
She is an EE (and Dance) major, junior at she identifies as

I'm not sure what to expect from this interview, but that seems like a good thing.
I'm back in Clemson.
I'm a little frustrated with being back, with the distractions that come with being back at home and in the office.
I'm pretty tired; although, I went to bed at a descent hour and slept well.

GRACE 10/11/2017

18 Post-Interview Memo

I think the interview went well. I feel a little overwhelmed thinking about it. It was complex, and I'm not sure where it fits in.
I used appear.in. It worked fine. She was in a public space. I could only see the wall / ceiling. But I could hear people. It seemed like a library or cafateria.
She got distracted by something I couldn't see. And it did kind of seem like she never completely got comfortable. She seemed to be in job interview mode.

SELYNE 10/11/2017

4. Pre-Interview Memo

I'm running short on time. But I feel good. She wanted to meet early, so I am going to do that.
I feel prepared.
She's a heterosexual junior in electrical engineering at
Her scores are on the higher end of the cuttoff, so I am a little unsure that she'll fit in with the target population.

SELYNE 10/11/2017

Post-Interview Memo

That was a whirl wind. I felt like I was not in control of the interview sometimes. She talked a lot, and fast. And she seemed uncomfortable with the ambiguity, or breadth of some of the questions.
She had difficulties with the connection in her room and had to move to the lounge / cafateria.
There was a <u>lot</u> of background noise. I had a hard time hearing her, and had to jot down some phrases that I thought might be hard to hear/understand when transcribing.
I didn't ask her to repeat herself often because she would be on a roll talking and I didn't want to interrupt the flow.

Appendix H QUAN Participant Recruitment Email

I'm an Engineering and Science Education Ph.D. student from Clemson University. I have started doing data collection for my dissertation work, and I was hoping you would be willing to give out one survey at the beginning of the Spring 2017 semester to your ***** course.

For my dissertation, I am looking at the connection between students' future goals and behaviors in the present. The first piece of the study includes a multi-institution distribution of a survey focused on engineering students' future goals. I am focusing on large enrollment classrooms in the hopes that I will be able to provide instructors with information about their students' motivations that they would not be able to know otherwise.

If you agree to distribute the survey I would ask you to:

> **Email Survey Link**: Send an email with a link to the survey to your students 2-4 weeks into the semester (late January or early February for GT). I will provide an email that you can forward, for your convenience, or you can write your own.
>
> **Optional:**
> **Introduce Study**: Introduce the study in class, so that the students expect the email. I will provide a summary for your convenience.
> **Provide 10 Minutes of Class Time**: If you are willing, please provide 10 minutes of class time to complete the survey.
> **Offer Incentives**: If you are willing or able to provide an extra incentive (i.e. extra credit, replacing an attendance grade), please let me know what you will need for me. We can set a deadline for completion, and I can return a list of the names of students who completed the survey within 12 hours

If you are interested, I will contact the IRB offices at ***** to determine what would be considered "engaged research." I would like to keep your workload as minimal as possible; I am sure you are very busy.

Could you please let me know if you would be willing to or are interested in distributing this survey and receiving information about your students' motivations and future goals? Collecting data from your ***** course at ***** would be particularly beneficial for me to get additional data from ***EE*** students at one of the largest engineering institutions in the nation.

I have attached a summary of the project and what participating would mean as well as a copy of the survey.

Thank you so much for your time, and I look forward to hearing from you!

(Attachment)

Instructions for Distributing the Survey
Future Goals and Problem Solving in Engineering

Overview of Directions: Two to four weeks into the first day of classes, we would like you to distribute the survey. You can choose to either hand out paper copies of the survey or provide a link for an electronic copy of the survey. Introduce the survey with a brief description of the study, then explain the students' participation in study in regard to what they need to do and how it may benefit them. I've provided a script below for these descriptions; you may want to follow these word-by-word or cover the main points in your own words. After describing the study and distributing the link or paper copies of the survey, you may leave the room to minimize the possibility of undue influence or coercion, if it is possible in your classroom. You may offer extra incentives for completing the survey, such as extra credit, but the student has an option to opt out of including their data in the study.

Description of the Study: This survey is for a graduate student, at Clemson University's, dissertation work, which is working towards improving personalized instruction in large enrollment engineering courses. This study approaches this problem by exploring how students' motivations and goals for the future are connected to how their actions in the present, specifically in regard to problem solving.

Students' Participation in Study: The information you provide on the survey will be used to help improve your instruction in the classroom, by informing me of your motivations. I will in no way see individual responses to the survey, but rather I will receive a description of the class's motivations with all identifying information removed. You will also receive [insert your own incentive if you wish to include one] for completing the survey. To receive this [benefit] you need to answer all of the questions, but if you would like your data to not be included in the study, there is an option on the survey you can select to opt out.

I will send you a link to access the survey [*or* pass out a copy of the survey]. [Additional instruction for them to receive your additional benefits, i.e. place your name on the top right corner of the first page to receive extra credit for completing the survey.] The survey should take about 10 minutes to complete. **Please answer the questions on the survey for [your large enrollment course].**

Appendix I QUAN Participant Recruitment Flyer

Information for Participation in a Research Study
Engineering Undergraduate's Motivations for Being in Engineering: Future Career Perceptions

We are looking for instructors of large engineering classes who are willing to distribute a survey to their students on student motivation and problem solving.

Description of the Research:

This study is part of a project exploring how students' motivations connect to how they are solving problems. As part of this research, a reliable survey instrument to measure students' perceptions of their future careers was developed and validated at two large land-grant institutions. This survey focuses on students' career goals and how they influence their actions in the present; the survey has about 30 items and takes about 10 minutes to complete.

This study aims to use this survey instrument to capture the ways undergraduate engineering students are perceiving their future careers and how that is affecting their behavior in the present. The study will target large-enrollment classrooms (classrooms with more than 50 students per instructor) to help instructors of these large classes gain insight into their students' motivations that they may not otherwise have the opportunity to discover.

What We Need:

Participants needed for this study are undergraduate engineering students in large enrollment classrooms. We would like to recruit these participants via their instructors. We would ask that the instructor to:

1. Distribute paper copies of the survey to students in their large enrollment class
2. Allow time for students to complete the survey, either in class or out of class (about 10 minutes)
3. Collect the surveys and send them back to the researcher using the return envelope provided

What You Will Receive:

In return, the instructor will be provided the results in the form of descriptive statistics and a written description of the results for their students. These results include a description of:

1. Their students' perceptions of their future careers
2. How their students' goals for the future affect what their students are doing in the present
3. How useful their students find their coursework
4. In what ways students find their coursework useful

The study will take place at the beginning of the Fall 2016 semester or the beginning of the Spring 2017 semester. If you are willing to distribute surveys for this study, please email Catherine McGough (cmcgoug@g.clemson.edu), or use the QR code to enter your contact information.

Researcher Contact Information:

Catherine McGough
cmcgoug@clemson.edu

Lisa Benson, Ph.D.
lbenson@clemson.edu
864.656.041

Department of Engineering and Science Education
Clemson University, Clemson SC 29634

Appendix J Electronic Survey Distribution Email

Hi!

I am a Ph.D. student in Engineering and Science Education at Clemson University, and for my dissertation I am looking at improving personalized instruction at large enrollment courses. I am exploring how students' motivations and goals for the future are connected to how their actions in the present, specifically in regard to problem solving.

In order to reach this goal, I first need to understand students' goals for the future. To do this, **I am asking for students to complete a 10 minute survey.**

The information you provide on the survey will be used to help improve your instruction in the classroom, by informing me of your motivations. Professor Ybarra will in no way see individual responses to the survey, but he will receive a description of the class's motivations with all identifying information removed.

To complete the survey, please follow the link below. Please answer the questions on the survey for ECE 220:

http://clemson.qualtrics.com//SE/?SID=SV_0DhM3Rt8iMdj9nn

If you have any questions or concerns about this study or if any problems arise, please contact Dr. Lisa Benson at Clemson University at 864.656.0417. If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

Appendix K Survey Instrument

Future-Oriented Motivation Constructs

An initial pool of items was refined using the existing survey instrument, Motivations and Attitudes in Engineering (MAE), Qualitative work (Q), Experts in the field (E), and Focus Groups (FG). The numbered items show the revised item, and the bullets under the items show previous versions of that item.

N1. There are multiple careers that I can imagine being rewarding. (FG)
- There are multiple career paths that I can imagine being rewarding for myself. (E)
- There are multiple careers that I can imagine I would find rewarding. (E)
- There are multiple career that I can imagine being rewarding for myself. (MAE)

D1. I am unsure what I want my future career to be. (FG)
- I am unsure what my future career will be. (MAE)

RI6. I believe I can obtain the career I want. (E)
RA1. I do not think I will enjoy the job I will have immediately after graduation. (FG)
- I think I will not enjoy the job I will have immediately after graduation. (E)
- I don't think I will enjoy the job I will be able to get after graduation. (Q)

D8. I do not worry about what I want to do after college. (E)
RI4. My ideal career is different from my realistic career. (Q)
N3. I am considering multiple careers. (MAE)
RI3. The career path I would find most rewarding is not realistic for me. (E)
- I do not think I can realistically obtain the career that would be the most rewarding for myself. (Q)
- I think I cannot obtain the career that I would find most rewarding. (E)

RA3. I think I will be satisfied with the career I will be able to achieve. (Q)
N2. I am considering multiple careers only as a backup plan. (E)
- I would like to explore multiple future careers. (Q)

D6. My future career is too far off to think about now. (FG)
- My career goals are too far off to think about now. (E)

D2. I have a clear idea of what my first job after graduation will be. (Q)
- I have a clear idea of the first job I will have after graduation (E)

RI5. The career I would I ideally want is different from a career I could realistically get. (E)
- I can become my ideal self. (Q)
- My ideal career is different from the one I can realistically obtain. (E)
- My ideal career is different from my realistic career. (E)
- I believe I can obtain the career I want. (E)

D7. My first job after graduation is something I think about daily. (E)
RI2. I will be able to follow the career path that would be the most rewarding for me. (E)
- I believe I can obtain the career that would be the most rewarding for myself. (Q)

N5. Although there is only one career I really want, I have at least one back up plan. (Q)
D3. I have a clear idea of what my future career will be in 10 years. (Q)
- I have a clear idea of the career I will have in 10 years. (E)

N4. There is only one career I can imagine that I would find rewarding. (E)

- There is only one career I can imagine being rewarding for myself. (Q)

RA2. The job offers I will be able to get after graduation are not the types of jobs I want. (FG)

- The jobs I will be able to get after graduation are not the types of jobs I want. (Q)

RI1. The career path I really want is not the career path I expect to have. (E)

- The career I believe I can have is not the same as the career I ideally want to have. (Q)
- The career I believe I may have is not the same as the career I ideally want to have. (E)
- I will be able to follow the career path that will be most rewarding for me. (E)

D5. My future career is too far off to consider now. (FG)

- My career goals are too far off to consider now. (E)

D5. I don't really have a set career goal. (Q)

- I don't like to plan for the future (MAE)

D4. I'm not exactly sure what I want to do after college. (Q)

- It's not really important to have future goals for where one wants to be in five or ten years. (MAE)

N36 I am actively looking into different careers. (FG)

PI5. The skills I learn in this course will be important for my future occupational success. (Q)

FoP5. My plans for my future career path do not affect the how I approach this course. (FG)

- My plans for my future career path do not affect the actions I take now. (Q)

PI1. I will use the information I learn in this course in the future. (MAE)

FoP6. I think about my future career to determine what is important in this course. (E)

FoP7. I focus on learning information that will help be successful in my career. (E)

FoP4. My future career is an important consideration in how I decide to approach this course. (FG)

- What will happen in my future career is an important consideration in deciding how to approach this course. (FG)
- What will happen in my future career is an important consideration in deciding what action to take now. (MAE)

FoP3. I do not connect my future career to what I am learning in this course. (MAE)

PI4. My course work is preparing me for my first job after graduation (E)

- My course work is preparing me for my first job. (MAE)

PI2. I will not use what I learn in this course. (MAE)

PI3. I will use the information I learn in this course in future courses. (FG)

- I will use the information I learn in this course in other classes I will take in the future. (MAE)

FoP1. My future career determines what is important to me in this course. (FG)

- My future career determines what is important in this course. (MAE)

FoP8. I do not make connections between my future career and what I am learning in this course. (E)

FoP2.My future career influences what I want to learn in this course. (FG)

- My future career influences what I learn in this course. (MAE)

The items were then compiled into a survey to distribute for pilot data. The items were intended to fit into six factors: Number of Future Possible Careers (N), Definition of Future Possible Careers (D), Matching Ideal and Realistic Future Possible Careers (RI), Matching Ideal and Avoided Future Possible Careers (RA), Endogenous Perceived Instrumentality (PI), and Effect of the Future on the Present (FoP)

N1	There are multiple careers that I can imagine being rewarding.
N2	I am considering multiple careers only as a backup plan.
N3	I am considering multiple careers.
N4	There is only one career I can imagine that I would find rewarding.
N5	Although there is only one career I really want, I have at least one back up plan.
N6	I am actively looking into different careers.
D1	I am unsure what I want my future career to be.
D2	I have a clear idea of what my first job after graduation will be.
D3	I have a clear idea of what my future career will be in 10 years.
D4	I'm not exactly sure what I want to do after college.
D5	I don't really have a set career goal.
D6	My future career is too far off to think about now.
D7	My first job after graduation is something I think about daily.
D8	I do not worry about what I want to do after college
D9	My future career is too far off to consider now.
RI1	The career path I really want is not the career path I expect to have.
RI2	I will be able to follow the career path that would be the most rewarding for me.
RI3	The career path I would find most rewarding is not realistic for me.
RI4	My ideal career is different from my realistic career.
RI5	The career I would I ideally want is different from a career I could realistically get.
RI6	I believe I can obtain the career I want.
RA1	I do not think I will enjoy the job I will have immediately after graduation.
RA2	The job offers I will be able to get after graduation are not the types of jobs I want.
RA3	I think I will be satisfied with the career I will be able to achieve.
PI1	I will use the information I learn in this course in the future.
PI2	I will not use what I learn in this course.
PI3	I will use the information I learn in this course in future courses.
PI4	My course work is preparing me for my first job after graduation.
PI5	The skills I learn in this course will be important for my future occupational success.
FoP1	My future career determines what is important to me in this course.
FoP2	My future career influences what I want to learn in this course.
FoP3	I do not connect my future career to what I am learning in this course.
FoP4	My future career is an important consideration in how I decide to approach this course.
FoP5	My plans for my future career path do not affect the how I approach this course.
FoP6	I think about my future career to determine what is important in this course.
FoP7	I focus on learning information that will help be successful in my career.
FoP8	I do not make connections between my future career and what I am learning in this course.

An exploratory factor analysis (EFA) indicated five factors which were identified as Definition of Future Possible Careers (D), Extension of Future Possible Careers (EX), Time Attitude (TA), Endogenous Perceived Instrumentality (PIEN), and Effect of Future on Present (FoP).

D1	I am unsure what I want my future career to be.
D2	I have a clear idea of what my first job after graduation will be.
D3	I have a clear idea of what my future career will be in 10 years.
D4	I'm not exactly sure what I want to do after college.
D5	I don't really have a set career goal.
E6	My future career is too far off to think about now.
E8	I do not worry about what I want to do after college.
E9	My future career is too far off to consider now.
AL1	The career path I really want is not the career path I expect to have.
AL2	I will be able to follow the career path that would be the most rewarding for me.
AL3	The career path I would find most rewarding is not realistic for me.
AL4	My ideal career is different from my realistic career.
AL5	The career I would I ideally want is different from a career I could realistically get.
AL6	I believe I can obtain the career I want.
AL7	I do not think I will enjoy the job I will have immediately after graduation.
AL8	The job offers I will be able to get after graduation are not the types of jobs I want.
AL9	I think I will be satisfied with the career I will be able to achieve.
PIEN1	I will use the information I learn in this course in the future.
PIEN2	I will not use what I learn in this course.
PIEN3	I will use the information I learn in this course in future courses.
PIEN4	My course work is preparing me for my first job after graduation.
PIEN5	The skills I learn in this course will be important for my future occupational success.
FoP1	My future career determines what is important to me in this course.
FoP2	My future career influences what I want to learn in this course.
FoP4	My future career is an important consideration in how I decide to approach this course.
FoP6	I think about my future career to determine what is important in this course.
FoP7	I focus on learning information that will help be successful in my career.

The survey included in the Exploratory QUAN Strand measured 7 factors. After speaking to experts in the field, the name of Time Attitude factor was changed to more accurately reflect what it is measuring—Alignment of Future Possible Careers. Three constructs from the MAE were added to the survey distributed in the QUAN strand (VU, PIEX, and PF)

Abbrev	Name of Factor	A high score indicates…
FoP	Effect of Future on Present	the student recognizes that their future goals affect what they do in the present
PIEN	Endogenous Perceived Instrumentality	the student finds their course useful for their future career
PIEX	Exogenous Perceived Instrumentality	the student finds their course grade to be useful for their future career
CL	Clarity of Future Possible Careers	the student has a well-defined future goal, deep into the future
VU	Value of the Future	The student perceives that there is value in thinking about long-term goals
AL	Alignment of Ideal and Realistic Future Possible Careers	The student has an ideal future possible career that is also realistic.
PF	Perceptions of the Future in Engineering	The student is certain about wanting to be an engineer.

The 31 items included in the survey measured the 7 factors, as indicated by the item abbreviation. The items in parenthesis are reverse coded. Survey was reduced in items to reduce time needed to complete the survey and reach more participants

FoP_1	I think about my future career to determine what is important in this course.
FoP_2	My future career influences what I want to learn in this course.
FoP_3	My future career is an important consideration in how I decide to approach this course.
PIEN_1	My course work is preparing me for my first job after graduation.
(PIEN_2)	I will not use what I learn in this course.
PIEN_3	The skills I learn in this course will be important for my future occupational success.
PIEN_4	I will use the information I learn in this course in the future.
PIEN_5	I will use the information I learn in this course in other classes I will take in the future.
(PIEX_1)	The grade I get in this course will not affect my ability to continue on with my education.
(PIEX_2)	What grade I get in this course will not be important for my future academic success.
PIEX_3	I must pass this course in order to reach my academic goals.
PIEX_4	The grade I get in this course will affect my future.
(CL_1)	I am unsure what I want my future career to be.
CL_2	I have a clear idea of what my first job after graduation will be.
CL_3	I have a clear idea of what my future career will be in 10 years.
(CL_4)	I'm not exactly sure what I want to do after college.
(CL_5)	I don't really have a set career goal.
(VU_1)	My future career is too far off to think about now.
(VU_2)	I do not worry about what I want to do after college.
(VU_3)	My future career is too far off to consider now.
VU_4	My long range goals are more important than my short range goals.
(AL_1)	The career path I would find most rewarding is not realistic for me.
(AL_2)	My ideal career is different from my realistic career.
(AL_3)	The career I would I ideally want is different from a career I could realistically get.
AL_4	I believe I can obtain the career I want.
(AL_5)	I do not think I will enjoy the job I will have immediately after graduation.
AL_6	I think I will be satisfied with the career I will be able to achieve.
PF_1	I am confident about my choice of major.
PF_2	Engineering is the most rewarding future career I can imagine for myself.
PF_3	My interest in an engineering major outweighs any disadvantages I can think of.
PF_4	I want to be an engineer.

Demographic Information

Demographic information and the description of the FTPs of the population. The demographic questions used in this survey are intended to represent the shift in social norms to include more dimensions of identities. The demographic questions were based on Fernandez et al. (2016). The demographic results from this study may aid in the

understanding of diversity in engineering as well as understanding how these different demographic measures affect their motivations and goal setting in engineering.

Students were given the option to select multiple responses when describing their racial, gender, and sexual identity to allow for students who do not identify with the predefined categories to accurately represent their identity. Also, open ended options were provided for students to further explain their result if they chose to do so.

The instrument included questions about academic demographics and social identity demographics. The academic demographic questions measured major, institution, course, and year in school. The social identity demographics measured the highest level of education for parents, nationality of self and parents, STEM background for parents, siblings, and other relatives, race/ethnicity, gender identity, and sexual identity. To minimize the threat of "stereotype threat," or priming the participant to consider their demographics while completing the in this survey was collected to aid in the selection of participants for the QUAL phase

construct items, the demographic items are asked at the end of the survey (Fernandez et al., 2016; Spencer, Steele, & Quinn, 1999; Steele, 1997; Steele & Aronson, 1995).

Electronic Format of the Instrument

Responses were not forced, but participants received reminders if a question was skipped. This format allows students to refuse to answer a question that they do not wish to answer while minimizing the chance that students will unintentionally skip a question.

The instrument was distributed over two semesters: Fall Year 3 and Spring Year 4; between the two semesters, the distribution process was streamlined, and there were some differences between the Fall 3 and Spring 4 instrument. In Fall 3, the questions for course and institutions were fill in the blank, making identifying that information difficult, so for Spring 4, a dropdown box for course and institution was used. The demographic question about family members' professions did not allow for multiple responses, making the data from this question invalid for Fall 3. For Spring 4, the question was changed to allow for multiple responses.

Information for Participation in a Research Study

Future Goals and Problems Solving in Engineering

Principal Investigator: Lisa Benson,
Ph.D. Department of Engineering and Science Education
Clemson University
864-656-0417
lbenson@clemson.edu

Description of the research and your participation: You are invited to participate in a research study assessing engineering students' problem-solving abilities and motivation. We are studying these factors through the use of surveys, interviews, and problem solving work. We will be studying the relationships, if any, to other student information, namely gender, ethnicity, sexual identity, and family background. These data will be collected through survey data. Your participation will involve completing an online or paper survey, which will take about 10 minutes to complete. You may also be invited to participate in further studies, including an interview, which will take about 2 hours to complete. With your permission, we would like to audio record these interviews.

Risks and discomforts: There are no known risks associated with this research.

Potential benefits: Your information may benefit your current classroom experience by provided feedback to your instructors, and your information may help future students by helping us make courses more effective. In addition, this research will be disseminated so that students and faculty at other institutions may benefit as well.

Incentives: Incentives for completing the survey will be specified by your instructor. You will receive the incentive regardless of your decision to participate in the study. For completing the interview, you will receive a $20 Amazon gift card.

Protection of confidentiality: We will do everything we can to protect your confidentiality. Your name will not be recorded in any way in the compiled survey, interview, or problems solving data. Your responses and transcripts will be marked with a code. Only the Principal Investigator (Dr. Benson) will have the key

which links your identity to that code, and this key will be destroyed as soon as all data have been collected and compiled. Your audio data will be kept on a secured hard drive and will be destroyed after the completion of the study. Your identity will not be revealed in any publication that might result from this study. Demographics will be limited and only used in aggregate.

Voluntary participation: You may choose not to participate and you may withdraw your consent to participate at any time. Your decision whether or not to participate in the research will not affect your course grades in any way.

Exclusion Requirements: Participants must be at least eighteen years of age to be eligible to participate.

Contact information: If you have any questions or concerns about this study or if any problems arise, please contact Dr. Lisa Benson at Clemson University at 864.656.0417. If you have any questions or concerns about your rights in this research study, please contact the Clemson University Office of Research Compliance (ORC) at 864-656-0636 or irb@clemson.edu. If you are outside of the Upstate South Carolina area, please use the ORC's toll-free number, 866-297-3071.

Please indicate if you are 18 years of age or older.
- ❍ I am 18 years of age or older.
- ❍ I am younger than 18 years of age.

What is your email? ____

What is your current major? ____

What institution do you attend? ____

What course and section/time are you completing this survey for?

____

The following questions relate to your attitudes and beliefs about your experiences in the course you listed above in question 4, and in your engineering major. Please rate your agreement for each item on a scale from “Strongly Disagree” to “Strongly Agree.”

	Strongly Disagree						Strongly Agree
I will use the information I learn in my engineering course in other classes I will take in the future.	❍	❍	❍	❍	❍	❍	❍
The grade I get in this course will not affect my ability to continue on with my education.	❍	❍	❍	❍	❍	❍	❍
I must pass this course in order to reach my academic goals.	❍	❍	❍	❍	❍	❍	❍
I do not worry about what I want to do after college.	❍	❍	❍	❍	❍	❍	❍
I do not think I will enjoy the job I will have immediately after graduation.	❍	❍	❍	❍	❍	❍	❍
I don’t really have a set career goal.	❍	❍	❍	❍	❍	❍	❍
I believe I can obtain the career I want.	❍	❍	❍	❍	❍	❍	❍
The grade I get in this course will affect my future.	❍	❍	❍	❍	❍	❍	❍
I have a clear idea of what my first job after graduation will be.	❍	❍	❍	❍	❍	❍	❍
I’m not exactly sure what I want to do after college.	❍	❍	❍	❍	❍	❍	❍
I will not use what I learn in this course.	❍	❍	❍	❍	❍	❍	❍
What grade I get in this course will not be important for my future academic success.	❍	❍	❍	❍	❍	❍	❍
My course work is preparing me for my first job after graduation.	❍	❍	❍	❍	❍	❍	❍
The career I would I ideally want is different from a career I could realistically get.	❍	❍	❍	❍	❍	❍	❍

The following questions relate to your attitudes and beliefs about your experiences in the course you listed above in question 4, and in your engineering major. Please rate your agreement for each item on a scale from “Strongly Disagree” to “Strongly Agree.”

	Strongly Disagree						Strongly Agree
The career path I would find most rewarding is not realistic for me.	❍	❍	❍	❍	❍	❍	❍
My future career influences what I want to learn in this course.	❍	❍	❍	❍	❍	❍	❍
My long range goals are more important than my short range goals.	❍	❍	❍	❍	❍	❍	❍
I will use the information I learn in this course in the future.	❍	❍	❍	❍	❍	❍	❍
I want to be an engineer.	❍	❍	❍	❍	❍	❍	❍
The skills I learn in this course will be important for my future occupational success.	❍	❍	❍	❍	❍	❍	❍
I think about my future career to determine what is important in this course.	❍	❍	❍	❍	❍	❍	❍
My ideal career is different from my realistic career.	❍	❍	❍	❍	❍	❍	❍
Engineering is the most rewarding future career I can imagine for myself.	❍	❍	❍	❍	❍	❍	❍
I think I will be satisfied with the career I will be able to achieve.	❍	❍	❍	❍	❍	❍	❍
I am confident about my choice of major.	❍	❍	❍	❍	❍	❍	❍
I am unsure what I want my future career to be.	❍	❍	❍	❍	❍	❍	❍
My future career is too far off to think about now.	❍	❍	❍	❍	❍	❍	❍
I have a clear idea of what my future career will be in 10 years.	❍	❍	❍	❍	❍	❍	❍
My interest in an engineering major outweighs any disadvantages I can think of.	❍	❍	❍	❍	❍	❍	❍
My future career is too far off to consider now.	❍	❍	❍	❍	❍	❍	❍
My future career is an important consideration in how I decide to approach this course.	❍	❍	❍	❍	❍	❍	❍

How would you describe your current year in your major?

❍ Freshman ❍Sophomore ❍Junior ❍Senior

What was the highest level of education for your parents/guardians?

	Less than high school diploma	High school diploma/GED	Some college or associate/ trade degree	Bachelor's degree	Master's degree or higher	Don't Know
Parent/Guardian #1	❍	❍	❍	❍	❍	❍
Parent/Guardian #2	❍	❍	❍	❍	❍	❍

Which category best fits you and your parent(s)' or guardian(s)' background?

Born in United States?

	Yes	No
Me	❍	❍
Parent/Guardian #1	❍	❍
Parent/Guardian #2	❍	❍

With which racial and ethnic group(s) do you identify? *Mark all that apply*.

❑ American Indian or Alaska Native
❑ Asian
❑ Black or African American
❑ Hispanic, Latino, or Spanish Origin
❑ Middle Eastern or North African
❑ Native Hawaiian or Other Pacific Islander
❑ White
❑ Some other race or ethnicity: ____________________

How do you describe your gender identity? *Mark all that apply*.

❑ Male
❑ Female
❑ Agender
❑ Genderqueer
❑ Cisgender
❑ Transgender
❑ A gender not listed: ____________________

How do you describe your sexual identity? *Mark all that apply*.

❑ Heterosexual/straight
❑ Homosexual/gay/lesbian
❑ Bisexual
❑ Asexual
❑ A sexuality not listed: ____________________

May we use the information you provided for this survey in our study?

❍ Yes ❍ No

Appendix L Data Collection Methods for Exploratory QUAN Phase by Institution

Univ	Course Name	Number of Students Enrolled	Number of Participants Consented	Distribution Method
A	Fundamentals of Environmental Engineering	150	14	Forwarded email with link outside of class
B	Introduction to Logic Design	145	4	Link posted on course website
	Introduction to Signals and Systems	135	51	Link posted on course website Announced survey in class
C	Computer Systems Programming	115	83	Announced in class Given class time to complete
	Principles of Electrical Engineering	230	26	Forwarded email with link Let class out 7 minutes early to complete the survey
	Analytical Foundations of Electrical Engineering	80	12	Forwarded email with link Let class out 7 minutes early to complete the survey
	Mechanics of Solids	52	31	Forwarded email with link day before class Allotted 10 minutes during class to complete the survey
	Engineering Thermodynamics 1	244	117	Forwarded email with link Allowed 10 minutes during class to complete the survey
	Engineering Mechanics- Statics	60	44	Forwarded email with link Allowed time during class to complete the survey
D	Introduction to Computer Programming	500	284	Announced in class Forwarded email with link in lab Received class credit
F	Introduction to Microprocessors	58	54	Announced in class Received class credit
	Engineering Materials (Instructor 1)	82	64	Announced in class Forwarded email with link outside of class Received class credit
	Engineering Materials (Instructor 2)	90		

Appendix M Explanatory QUAL Interview Protocol

McGough QUAL Strand Interview Protocol

Explain the study: Interested in understanding in more depth how engineering students are thinking about their futures, and how those thoughts or goals relate to the present.

Go Over their Rights as a Participant: Read over the consent form, and sign if you agree. The consent form describes your rights as a participant in the study. Your identity will be protected. Your agreeing for the information you share today to be used in this study, but identifying information (name, institution, etc.) will be removed. You can contact me and ask to be removed from the study at any time. I may contact you with follow-up questions if after this interview, I have concerns about accurately representing your story. This interview will be audio recorded.

Logistics of the Interview: This interview will be audio recorded, and I will use a backup recorder. I may take notes during the interview to help me remember to ask a question without interrupting you. There are no right or wrong answers, I am interested in your thoughts and perceptions. You can have a copy of the interview questions

Future Possible Careers (Clarity and Alignment)

What are your goals for the future?

What are your personal goals for the future?
What are your career goals for the future?
Describe where you see yourself in 10 years?
Can you think of anything that could make you change your goals?

What would you ideally like to be in the future?

If you could pick one thing and it could happen what would it be?
If you could pick a professional goal to attain what would it be?

What do you think you can be in the future?

What are you actively striving for?
What goals are you currently pursuing to reach this future?

What do you not want to be in the future?

In other words, what jobs, or careers do you know you do not want to pursue?

Connection to the Present (Perceived Instrumentality and Effect of Future on Present)

What parts of your education do you see as relevant to your future?

What skills are relevant to ideal self)?
What skills are relevant to who you think you could be?
How do you see your education playing into your career?

What skills do you view as important for your profession?

What kind of profession (if more than one profession mentioned)?

How do your future goals affect how you approach the problems you solve?

In your classes? Internships/co-ops

How do your future goals affect your actions with respect to your courses?

What do you do when you fail achieving your goal in engineering?

What do you define failure as?
What do when you struggle to get to an answer?

How do you define success?
How important are grades?

Why are grades important to you?

<u>Experiences in Engineering (PF)</u>

What do you consider to be a career in engineering?

How long do you see yourself remaining in engineering?

How would you describe your overall experience in engineering?

Would you describe it as a positive? Negative? Neutral experience?

Why did you pursue your current engineering degree?

What did you know about engineering before starting at college?
Did you have external input on choosing your major? From family? Advisors?

<u>Follow-Up Survey Questions</u> (customized for each person)

On a scale of 1 to 7, 1 being strongly disagree and 7 being strongly agree how much do you agree with the statement:

(Survey Item) *(Response at Distribution 2)*

We expect these constructs will change some over time, but if you can, can you describe how you were interpreting that item at that time, and if those perceptions have changed, can you explain why?

Background Information

What level of engineering are you in?

What coursework have you completed?

What is your major?

What experiences do you have outside of the classroom related to engineering?

Co-op, internship, research, creative inquiry, etc.

What would you like your pseudonym to be?

I will replace your name with a pseudonym to protect your identity.

Appendix N R Code Used in Quantitative Strands

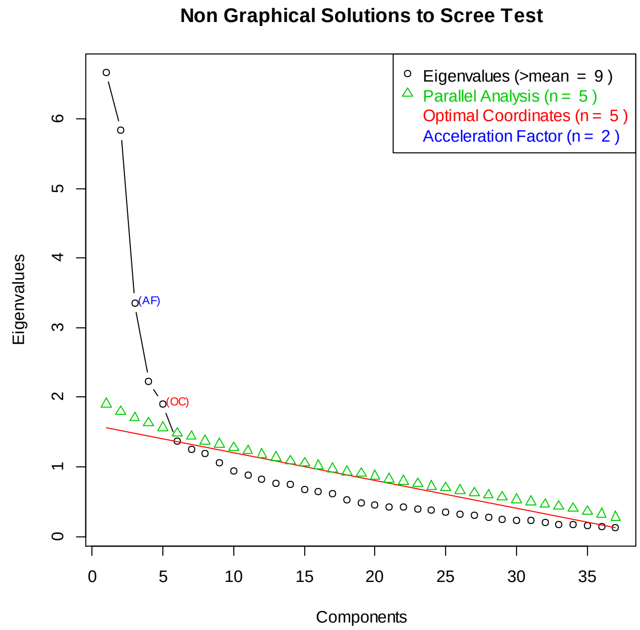
Survey Development Phase

```
R version 3.3.3 (2017-03-06) -- "Another Canoe"
Copyright (C) 2017 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

R is free software and comes with ABSOLUTELY NO WARRANTY.
You are welcome to redistribute it under certain conditions.
Type 'license()' or 'licence()' for distribution details.

R is a collaborative project with many contributors.
Type 'contributors()' for more information and
'citation()' on how to cite R or R packages in publications.

Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

[Workspace loaded from ~/.RData]

> library(car)
Loading required package: carData
> library(stats)
> library(psych)
Attaching package: ‘psych’

The following object is masked from ‘package:car’:

    logit

> library(nFactors)
Loading required package: MASS
Loading required package: boot

Attaching package: ‘boot’

The following object is masked from ‘package:psych’:

    logit

The following object is masked from ‘package:car’:

    logit

Loading required package: lattice

Attaching package: ‘lattice’

The following object is masked from ‘package:boot’:

    melanoma


Attaching package: ‘nFactors’
```

```
The following object is masked from ‘package:lattice’:

    parallel

> library(Hmisc)
Loading required package: survival

Attaching package: ‘survival’

The following object is masked from ‘package:boot’:

    aml

Loading required package: Formula
Loading required package: ggplot2
Need help getting started? Try the cookbook for R: http://www.cookbook-r.com/Graphs/

Attaching package: ‘ggplot2’

The following objects are masked from ‘package:psych’:

    %+%, alpha


Attaching package: ‘Hmisc’

The following object is masked from ‘package:psych’:

    describe

The following objects are masked from ‘package:base’:

    format.pval, units

> library(cluster)
> library(fpc)
>
> myData <-read.csv(file.choose()) #Attach pilot data
> attach(myData)
The following objects are masked _by_ .GlobalEnv:

    Gender, Major, Race, Year
>
> ###########   DATA CLEANING   ############
>
> myData$N2 <- recode(myData$N2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$N2 <- recode(myData$N2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$N4 <- recode(myData$N4, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$N4 <- recode(myData$N4, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$N5 <- recode(myData$N5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$N5 <- recode(myData$N5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$D1 <- recode(myData$D1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D1 <- recode(myData$D1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
```

```
>
> myData$D4 <- recode(myData$D4, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D4 <- recode(myData$D4, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$D5 <- recode(myData$D5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D5 <- recode(myData$D5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$D6 <- recode(myData$D6, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D6 <- recode(myData$D6, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$D8 <- recode(myData$D8, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D8 <- recode(myData$D8, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$D9 <- recode(myData$D9, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$D9 <- recode(myData$D9, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RI1 <- recode(myData$RI1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RI1 <- recode(myData$RI1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RI3 <- recode(myData$RI3, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RI3 <- recode(myData$RI3, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RI4 <- recode(myData$RI4, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RI4 <- recode(myData$RI4, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RI5 <- recode(myData$RI5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RI5 <- recode(myData$RI5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RA1 <- recode(myData$RA1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RA1 <- recode(myData$RA1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$RA2 <- recode(myData$RA2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$RA2 <- recode(myData$RA2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$PI2 <- recode(myData$PI2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$PI2 <- recode(myData$PI2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$FoP3 <- recode(myData$FoP3, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$FoP3 <- recode(myData$FoP3, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$FoP5 <- recode(myData$FoP5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$FoP5 <- recode(myData$FoP5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$FoP8 <- recode(myData$FoP8, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$FoP8 <- recode(myData$FoP8, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> ############ EFA ##############
> #Create dataset with all items from pilot
> ftp <-as.data.frame(cbind('N1'=myData$N1,'N2'=myData$N2,'N3'=myData$N3,'N4'=myData$N4,'N5'=myDa
ta$N5,'N6'=myData$N6,'D1'=myData$D1,'D2'=myData$D2,'D3'=myData$D3,'D4'=myData$D4,'D5'=myData$D5,'
D6'=myData$D6,'D7'=myData$D7,'D8'=myData$D8,'D9'=myData$D9,'RI1'=myData$RI1,'RI2'=myData$RI2,'RI3
'=myData$RI3,'RI4'=myData$RI4,'RI5'=myData$RI5,'RI6'=myData$RI6,'RA1'=myData$RA1,'RA2'=myData$RA2
,'RA3'=myData$RA3,'PI1'=myData$PI1,'PI2'=myData$PI2,'PI3'=myData$PI3,'PI4'=myData$PI4,'PI5'=myDat
a$PI5,'FoP1'=myData$FoP1,'FoP2'=myData$FoP2,'FoP3'=myData$FoP3,'FoP4'=myData$FoP4,'FoP5'=myData$F
oP5,'FoP6'=myData$FoP6,'FoP7'=myData$FoP7,'FoP8'=myData$FoP8))
> ftp <-na.omit(ftp)
> nrow(ftp) #RESULT: n=176
```

```
[1] 176
>
> #Determine number of factors
> ev <-eigen(cor(ftp))
> ap <-parallel(subject=nrow(ftp),var=ncol(ftp),rep=100,cent=.05)
> ns <-nScree(x=ev$values,aparallel=ap$eigen$qevpea)
> windows()
> plotnScree(nS)
```




```
> #RESULTS: Scree plot indicates 6 factors
>
> #Maximum Likelihood Factor Analysis
> fit<-factanal(ftp,6,rotation="promax") #6 factors and promax rotation
> print(fit,digits=2,cutoff=.4,sort=TRUE) #only shows items with loadings >0.4

Call:
factanal(x = ftp, factors = 6, rotation = "promax")

Uniquenesses:
  N1   N2   N3   N4   N5   N6   D1   D2   D3   D4   D5   D6   D7   D8   D9  RI1  RI2  RI3  RI4  R
I5  RI6  RA1  RA2  RA3  PI1  PI2  PI3  PI4  PI5 FoP1 FoP2 FoP3
0.85 0.76 0.78 0.56 0.63 0.82 0.38 0.64 0.52 0.29 0.37 0.36 0.79 0.79 0.13 0.36 0.54 0.44 0.50 0.
34 0.51 0.59 0.54 0.67 0.35 0.29 0.35 0.66 0.25 0.23 0.42 0.35
FoP4 FoP5 FoP6 FoP7 FoP8
0.25 0.77 0.35 0.62 0.52

Loadings:
     Factor1 Factor2 Factor3 Factor4 Factor5 Factor6
RI1   0.73
RI2   0.58
RI3   0.67
RI4   0.59
RI5   0.77
RI6   0.58
RA1   0.62
RA2   0.60
RA3   0.57
```

```
FoP1         0.98
FoP2         0.81
FoP4         0.80
FoP6         0.74
PI1                  0.87
PI3                  0.80
PI4                  0.53
PI5                  0.84
D1                           0.77
D3                           0.51
D4                           0.77
D5                           0.56
PI2                  0.51            0.66
FoP3                                 0.68
FoP8                                 0.53
D6                                           0.66
D9                                           0.93
N1
N2
N3                          -0.43
N4
N5
N6
D2                           0.48
D7
D8
FoP5                                 0.43
FoP7         0.47

               Factor1 Factor2 Factor3 Factor4 Factor5 Factor6
SS loadings       4.29    3.98    3.16    2.84    2.23    1.80
Proportion Var    0.12    0.11    0.09    0.08    0.06    0.05
Cumulative Var    0.12    0.22    0.31    0.39    0.45    0.49

Factor Correlations:
        Factor1 Factor2 Factor3 Factor4 Factor5 Factor6
Factor1   1.000  -0.030  -0.575  -0.025  0.0138 -0.0155
Factor2  -0.030   1.000   0.058   0.401 -0.2175  0.1535
Factor3  -0.575   0.058   1.000  -0.105  0.2470  0.1554
Factor4  -0.025   0.401  -0.105   1.000 -0.1910  0.2472
Factor5   0.014  -0.217   0.247  -0.191  1.0000  0.0024
Factor6  -0.015   0.153   0.155   0.247  0.0024  1.0000

Test of the hypothesis that 6 factors are sufficient.
The chi square statistic is 734.92 on 459 degrees of freedom.
The p-value is 4.31e-15
> #RESULTS: many items do not load, including number  items
>
> #Create new model to test fit indicated by EFA
> ftp1 <-as.data.frame(cbind('D1'=myData$D1,'D2'=myData$D2,'D3'=myData$D3,'D4'=myData$D4,'D5'=myD
ata$D5,'D6'=myData$D6,'D7'=myData$D8,'D9'=myData$D9,'RI1'=myData$RI1,'RI2'=myData$RI2,'RI3'=myDat
a$RI3,'RI4'=myData$RI4,'RI5'=myData$RI5,'RI6'=myData$RI6,'RA1'=myData$RA1,'RA2'=myData$RA2,'RA3'=
myData$RA3,'PI1'=myData$PI1,'PI2'=myData$PI2,'PI3'=myData$PI3,'PI4'=myData$PI4,'PI5'=myData$PI5,'
FoP1'=myData$FoP1,'FoP2'=myData$FoP2,'FoP4'=myData$FoP4,'FoP6'=myData$FoP6,'FoP7'=myData$FoP7))
> ftp1 <-na.omit(ftp1)
>
> fit<-factanal(ftp1,5,rotation="promax")
```

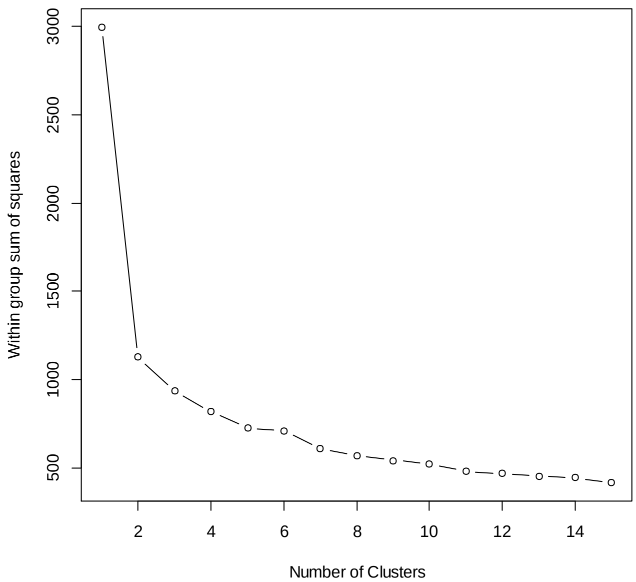
```
> print(fit,digits=2,cutoff=.4,sort=TRUE)

Call:
factanal(x = ftp1, factors = 5, rotation = "promax")

Uniquenesses:
  D1   D2   D3   D4   D5   D6   D7   D9  RI1  RI2  RI3  RI4  RI5  RI6  RA1  RA2  RA3  PI1  PI2  P
I3  PI4  PI5 FoP1 FoP2 FoP4 FoP6 FoP7
0.40 0.64 0.59 0.27 0.35 0.28 0.79 0.29 0.33 0.70 0.48 0.56 0.33 0.75 0.59 0.55 0.71 0.35 0.50 0.
37 0.68 0.23 0.14 0.38 0.32 0.38 0.58

Loadings:
     Factor1 Factor2 Factor3 Factor4 Factor5
RI1   0.81
RI2   0.51
RI3   0.65
RI4   0.60
RI5   0.82
RI6   0.50
RA1   0.62
RA2   0.66
RA3   0.53
PI1           0.84
PI2           0.68
PI3           0.79
PI4           0.51
PI5           0.87
FoP1                  1.01
FoP2                  0.80
FoP4                  0.65
FoP6                  0.65
FoP7                  0.53
D1                            0.79
D2                            0.56
D3                            0.56
D4                            0.81
D5                            0.59
D6                                    0.78
D9                                    0.79
D7                                    0.46

               Factor1 Factor2 Factor3 Factor4 Factor5
SS loadings       3.91    3.15    3.11    2.39    1.70
Proportion Var    0.14    0.12    0.12    0.09    0.06
Cumulative Var    0.14    0.26    0.38    0.46    0.53

Factor Correlations:
        Factor1 Factor2 Factor3 Factor4 Factor5
Factor1  1.0000 -0.0016  -0.483   0.043   0.287
Factor2 -0.0016  1.0000   0.035   0.338   0.413
Factor3 -0.4831  0.0347   1.000  -0.074   0.045
Factor4  0.0425  0.3380  -0.074   1.000   0.255
Factor5  0.2868  0.4134   0.045   0.255   1.000

Test of the hypothesis that 5 factors are sufficient.
The chi square statistic is 397.02 on 226 degrees of freedom.
The p-value is 1.58e-11
```

```
> #RESULTS: Looks good. I'll define the resulting factors below
>
> ################### FACTORS ############################
> #Clarity
> #Some of the depth items are actually describing how clear or well-defined the future is
> CL <-subset(myData,select=c("D1","D2","D3","D4","D5"))
> CL <-na.omit(CL)
> psych::alpha(CL) #RESULT: alpha=0.82

Reliability analysis
Call: psych::alpha(x = CL)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
      0.82      0.82    0.81      0.47 4.4 0.022    4 1.4     0.44

 lower alpha upper     95% confidence boundaries
0.77 0.82 0.86

 Reliability if an item is dropped:
   raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
D1      0.77      0.77    0.75      0.45 3.3    0.029 0.0160  0.44
D2      0.81      0.81    0.78      0.51 4.2    0.024 0.0208  0.49
D3      0.81      0.81    0.78      0.51 4.1    0.024 0.0237  0.51
D4      0.74      0.74    0.70      0.41 2.8    0.033 0.0088  0.39
D5      0.78      0.78    0.75      0.46 3.5    0.028 0.0127  0.44

 Item statistics
     n raw.r std.r r.cor r.drop mean  sd
D1 176  0.79  0.79  0.73   0.65  4.0 1.8
D2 176  0.69  0.69  0.57   0.51  3.3 1.8
D3 176  0.70  0.70  0.57   0.52  3.5 1.9
D4 176  0.85  0.85  0.84   0.74  4.3 1.8
D5 176  0.76  0.77  0.70   0.62  4.8 1.7

Non missing response frequency for each item
      1    2    3    4    5    6    7 miss
D1 0.15 0.06 0.18 0.20 0.17 0.15 0.09    0
D2 0.18 0.22 0.16 0.18 0.12 0.10 0.05    0
D3 0.20 0.15 0.14 0.18 0.16 0.11 0.06    0
D4 0.08 0.10 0.18 0.16 0.15 0.18 0.14    0
D5 0.02 0.11 0.15 0.14 0.12 0.27 0.18    0
>
> #Depth
> #The remaining depth items are actually measuring depth
> D <-subset(myData,select=c("D6","D8","D9"))
> D <-na.omit(D)
> psych::alpha(D) #RESULTS: alpha=0.72

Reliability analysis
Call: psych::alpha(x = D)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
      0.72      0.72    0.68      0.47 2.6 0.038  5.1 1.4     0.36

 lower alpha upper     95% confidence boundaries
0.64 0.72 0.79
```

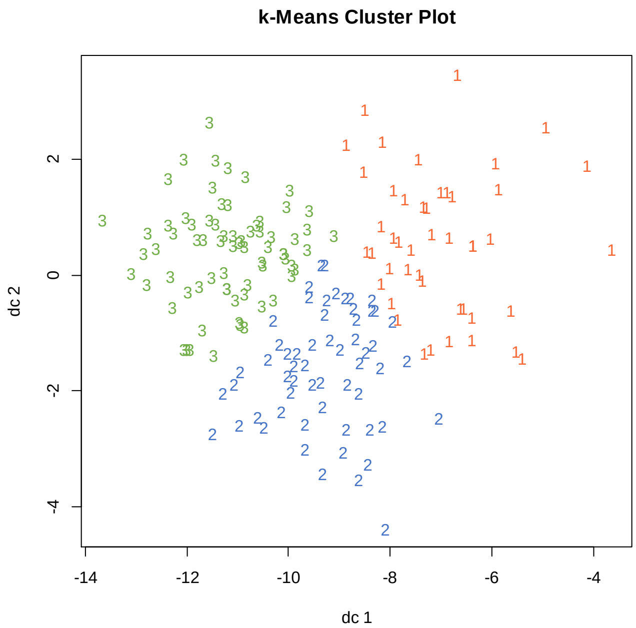
```
 Reliability if an item is dropped:
   raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
D6      0.53      0.53    0.36      0.36 1.1    0.070    NA  0.36
D8      0.82      0.82    0.70      0.70 4.7    0.026    NA  0.70
D9      0.50      0.50    0.34      0.34 1.0    0.075    NA  0.34

 Item statistics
     n raw.r std.r r.cor r.drop mean  sd
D6 176  0.84  0.85  0.77   0.62  5.1 1.7
D8 176  0.72  0.71  0.42   0.38  4.9 1.9
D9 176  0.84  0.86  0.79   0.64  5.4 1.6

Non missing response frequency for each item
      1    2    3    4    5    6    7 miss
D6 0.06 0.04 0.09 0.14 0.18 0.23 0.26    0
D8 0.05 0.08 0.14 0.12 0.15 0.19 0.27    0
D9 0.03 0.04 0.07 0.15 0.13 0.24 0.34    0
>
> #Alignment
> #The RI and RA items combine to measure how the ideal and realistic future possible careers ali
gn
> AL <-subset(myData,select=c("RI1","RI2","RI3","RI4","RI5","RI6","RA1","RA2","RA3"))
> AL <-na.omit(AL)
> psych::alpha(AL) #RESULTS: alpha=0.86

Reliability analysis
Call: psych::alpha(x = AL)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean sd median_r
      0.86      0.86    0.87       0.4   6 0.015    5  1     0.39

 lower alpha upper     95% confidence boundaries
0.83 0.86 0.89

 Reliability if an item is dropped:
    raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
RI1      0.83      0.83    0.84      0.38 4.9    0.018 0.015  0.38
RI2      0.85      0.85    0.85      0.41 5.6    0.016 0.017  0.40
RI3      0.83      0.83    0.85      0.39 5.0    0.018 0.018  0.38
RI4      0.85      0.85    0.85      0.41 5.5    0.017 0.014  0.39
RI5      0.82      0.83    0.83      0.37 4.8    0.019 0.013  0.38
RI6      0.86      0.85    0.86      0.42 5.9    0.015 0.013  0.40
RA1      0.85      0.85    0.86      0.41 5.5    0.017 0.018  0.38
RA2      0.84      0.84    0.86      0.40 5.4    0.017 0.017  0.39
RA3      0.85      0.85    0.86      0.41 5.6    0.016 0.019  0.40

 Item statistics
      n raw.r std.r r.cor r.drop mean  sd
RI1 176  0.79  0.78  0.76   0.71  4.9 1.6
RI2 176  0.60  0.64  0.59   0.50  5.3 1.2
RI3 176  0.76  0.74  0.70   0.67  4.8 1.8
RI4 176  0.69  0.65  0.61   0.57  4.5 1.8
RI5 176  0.83  0.81  0.81   0.76  4.7 1.8
RI6 176  0.52  0.58  0.52   0.42  6.0 1.1
RA1 176  0.67  0.66  0.59   0.56  4.4 1.5
RA2 176  0.67  0.67  0.61   0.57  4.9 1.5
RA3 176  0.59  0.63  0.55   0.50  5.7 1.1
```

```
Non missing response frequency for each item
       1    2    3    4    5    6    7 miss
RI1 0.03 0.03 0.14 0.16 0.21 0.27 0.16    0
RI2 0.01 0.01 0.05 0.16 0.31 0.31 0.15    0
RI3 0.05 0.07 0.10 0.16 0.17 0.24 0.19    0
RI4 0.09 0.06 0.12 0.24 0.14 0.22 0.13    0
RI5 0.06 0.09 0.09 0.22 0.15 0.23 0.16    0
RI6 0.01 0.01 0.01 0.09 0.15 0.35 0.40    0
RA1 0.04 0.07 0.16 0.23 0.23 0.19 0.07    0
RA2 0.02 0.05 0.13 0.20 0.23 0.22 0.15    0
RA3 0.00 0.02 0.02 0.10 0.23 0.37 0.26    0
>
> #Perceived Instrumentality
> #held together
> PI <-subset(myData,select=c("PI1","PI2","PI3","PI4","PI5"))
> PI <-na.omit(PI)
> psych::alpha(PI) #RESULTS: alpha=0.83

Reliability analysis
Call: psych::alpha(x = PI)

  raw_alpha std.alpha G6(smc) average_r S/N  ase mean  sd median_r
      0.83      0.83    0.82       0.5   5 0.02  4.2 1.3     0.47

 lower alpha upper     95% confidence boundaries
0.79 0.83 0.87

 Reliability if an item is dropped:
    raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
PI1      0.78      0.78    0.75      0.47 3.5    0.028 0.020  0.46
PI2      0.84      0.84    0.81      0.57 5.2    0.020 0.014  0.57
PI3      0.77      0.78    0.75      0.46 3.5    0.028 0.022  0.46
PI4      0.83      0.84    0.81      0.56 5.1    0.021 0.014  0.55
PI5      0.76      0.76    0.72      0.44 3.2    0.030 0.016  0.45

 Item statistics
      n raw.r std.r r.cor r.drop mean  sd
PI1 176  0.82  0.83  0.79   0.71  4.5 1.6
PI2 176  0.68  0.67  0.53   0.49  4.3 1.8
PI3 176  0.83  0.83  0.78   0.72  4.0 1.7
PI4 176  0.68  0.68  0.55   0.50  4.3 1.7
PI5 176  0.87  0.86  0.84   0.76  3.9 1.8

Non missing response frequency for each item
       1    2    3    4    5    6    7 miss
PI1 0.04 0.12 0.09 0.18 0.34 0.10 0.13    0
PI2 0.07 0.12 0.10 0.26 0.15 0.16 0.12    0
PI3 0.07 0.15 0.14 0.23 0.23 0.12 0.07    0
PI4 0.07 0.10 0.16 0.20 0.19 0.16 0.11    0
PI5 0.12 0.15 0.08 0.23 0.23 0.09 0.09    0
>
> #Future on Present
> #Remaining FoP items
> FOP <-subset(myData,select=c("FoP1","FoP2","FoP4","FoP6","FoP7"))
> FOP <-na.omit(FOP)
> psych::alpha(FOP) #RESULTS: alpha=0.87
```

```
Reliability analysis
Call: psych::alpha(x = FOP)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
      0.87      0.87    0.87      0.58 6.9 0.015  4.4 1.3     0.55

 lower alpha upper     95% confidence boundaries
0.84 0.87 0.9

 Reliability if an item is dropped:
     raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
FoP1      0.82      0.82    0.79      0.53 4.6    0.022 0.0160  0.53
FoP2      0.85      0.85    0.83      0.59 5.8    0.018 0.0130  0.58
FoP4      0.83      0.83    0.81      0.55 4.9    0.021 0.0167  0.55
FoP6      0.84      0.84    0.82      0.56 5.2    0.020 0.0169  0.54
FoP7      0.88      0.88    0.87      0.65 7.5    0.015 0.0081  0.65

 Item statistics
       n raw.r std.r r.cor r.drop mean  sd
FoP1 176  0.88  0.88  0.86   0.80  4.3 1.6
FoP2 176  0.79  0.80  0.74   0.67  4.3 1.6
FoP4 176  0.86  0.85  0.82   0.76  4.1 1.7
FoP6 176  0.84  0.84  0.79   0.74  4.1 1.7
FoP7 176  0.70  0.71  0.58   0.54  5.0 1.5

Non missing response frequency for each item
        1    2    3    4    5    6    7 miss
FoP1 0.05 0.10 0.19 0.18 0.23 0.15 0.10    0
FoP2 0.06 0.09 0.14 0.21 0.24 0.19 0.07    0
FoP4 0.07 0.14 0.14 0.21 0.22 0.12 0.10    0
FoP6 0.06 0.16 0.15 0.20 0.20 0.12 0.09    0
FoP7 0.02 0.06 0.11 0.14 0.27 0.22 0.19    0
>
> ################### CLUSTER ANALYSIS #######################
> myData$kCL <-(myData$D1+myData$D2+myData$D3+myData$D4+myData$D5)/5
> myData$kD <-(myData$D6+myData$D8+myData$D9)/3
> myData$kAL <-(myData$RI1+myData$RI2+myData$RI3+myData$RI4+myData$RI5+myData$RI6+myData$RA1+myDa
ta$RA2+myData$RA3)/9
> myData$kPI <-(myData$PI1+myData$PI2+myData$PI3+myData$PI4+myData$PI5)/5
> myData$kFOP <-(myData$FoP1+myData$FoP2+myData$FoP4+myData$FoP6+myData$FoP7)/5
>
> FTP <-myData[c("kD","kCL","kAL","kPI","kFOP")]
>
> #determine the number of clusters
> wss <- (nrow(FTP)-1)*sum(apply(FTP, 3, var))
> for (i in 2:15) wss[i] <- sum(kmeans(FTP,centers=i)$withinss)
> windows()
>plot(1:15,wss,type="b",xlab="Number of Clusters", ylab="Within group sum of squares")
```




```
> #RESULTS: indicates 2 to 3 factors
> fit <- kmeans(FTP,3,iter.max = 500,nstart=100) #run kmeans cluster analysis for k=K, for 100 ra
ndom sets
> #get cluster means and lengths
> aggregate (FTP,by=list(fit$cluster),FUN=mean)
  Group.1       kD      kCL      kAL      kPI     kFOP
1       1 3.246377 3.278261 4.304348 4.104348 4.104348
2       2 5.724138 2.982759 4.785441 4.196552 4.327586
3       3 5.861111 5.269444 5.646605 4.238889 4.552778
> aggregate (FTP,by=list(fit$cluster), FUN=length)
  Group.1 kD kCL kAL kPI kFOP
1       1 46  46  46  46   46
2       2 58  58  58  58   58
3       3 72  72  72  72   72
> #RESULTS: Cluster 1=SUGAR,  2=CAKE,  3=WAFFLE
> #Plotting Solution
> vcol<-c("#f66733","#4472c4","#70ad47") #Set colors for clusters to match dissertation graphcis
> windows()
> plotcluster(cbind(FTP$kCL, FTP$kAL, FTP$kD),fit$cluster,main="k-Means Cluster Plot",col=vcol[fi
t$cluster])
```



Exploratory QUAN Phase

```
R version 3.3.3 (2017-03-06) -- "Another Canoe"
Copyright (C) 2017 The R Foundation for Statistical Computing
Platform: x86_64-w64-mingw32/x64 (64-bit)

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Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

[Workspace loaded from ~/.RData]

> library(lavaan)
This is lavaan 0.5-23.1097
lavaan is BETA software! Please report any bugs.
> library(car)
Loading required package: carData
> library(stats)
> library(psych)

Attaching package: ‘psych’

The following object is masked from ‘package:car’:

    logit

The following object is masked from ‘package:lavaan’:
```

```
    cor2cov

> library(nFactors)
Loading required package: MASS
Loading required package: boot

Attaching package: ‘boot’

The following object is masked from ‘package:psych’:

    logit

The following object is masked from ‘package:car’:

    logit

Loading required package: lattice

Attaching package: ‘lattice’

The following object is masked from ‘package:boot’:

    melanoma


Attaching package: ‘nFactors’

The following object is masked from ‘package:lattice’:

    parallel

> library(Hmisc)
Loading required package: survival

Attaching package: ‘survival’

The following object is masked from ‘package:boot’:

    aml

Loading required package: Formula
Loading required package: ggplot2
Need help getting started? Try the cookbook for R: http://www.cookbook-r.com/Graphs/

Attaching package: ‘ggplot2’

The following objects are masked from ‘package:psych’:

    %+%, alpha


Attaching package: ‘Hmisc’

The following object is masked from ‘package:psych’:

    describe
```

```
The following objects are masked from ‘package:base’:

    format.pval, units

> library(cluster)
> library(fpc)
> library(moments)
> library(psy)

Attaching package: ‘psy’

The following object is masked from ‘package:psych’:

    wkappa

> library(plyr)

Attaching package: ‘plyr’

The following objects are masked from ‘package:Hmisc’:

    is.discrete, summarize

>
> #Attach the survey data with all identifiers removed
> myData <-read.csv(file.choose()) #Choose "All Data Cleaned.csv"
> attach(myData)
The following objects are masked _by_ .GlobalEnv:

    Course, Duel, Emphasis, Fam_Eng, Fam_non, Fam_STEM, Gender, Major, Me_US, Parent1_Ed, Parent1
_US, Parent2_Ed, Parent2_US, Race, Univ, Year

>
> ###########   DATA CLEANING   ############
>
> #Reverse Code negatively worded items (using 7 point scale)
>
> myData$PIEN_2 <- recode(myData$PIEN_2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$PIEN_2 <- recode(myData$PIEN_2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$PIEX_1 <- recode(myData$PIEX_1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$PIEX_1 <- recode(myData$PIEX_1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$PIEX_2 <- recode(myData$PIEX_2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$PIEX_2 <- recode(myData$PIEX_2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$C_1 <- recode(myData$C_1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$C_1 <- recode(myData$C_1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$C_4 <- recode(myData$C_4, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$C_4 <- recode(myData$C_4, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$C_5 <- recode(myData$C_5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$C_5 <- recode(myData$C_5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$V_1 <- recode(myData$V_1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
```

```
> myData$V_1 <- recode(myData$V_1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$V_2 <- recode(myData$V_2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$V_2 <- recode(myData$V_2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$V_3 <- recode(myData$V_3, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$V_3 <- recode(myData$V_3, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$TA_1 <- recode(myData$TA_1, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$TA_1 <- recode(myData$TA_1, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$TA_2 <- recode(myData$TA_2, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$TA_2 <- recode(myData$TA_2, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$TA_3 <- recode(myData$TA_3, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$TA_3 <- recode(myData$TA_3, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> myData$TA_5 <- recode(myData$TA_5, '1=9; 2=8; 3=10; 4=4; 5=11; 6=12; 7=13')
> myData$TA_5 <- recode(myData$TA_5, '9=7; 8=6; 10=5; 4=4; 11=3; 12=2; 13=1')
>
> ############################ DEFINE DATASETS #############################
>
> #creating data set using all of the intended FTP items, and labeling their column names.
> FTP <-as.data.frame(cbind("ID"=as.character(myData$ID),"FoP_1"=myData$FoP_1,"FoP_2"=myData$FoP_
2,"FoP_3"=myData$FoP_3,"PIEN_1"=myData$PIEN_1,"PIEN_2"=myData$PIEN_2,"PIEN_3"=myData$PIEN_3,"PIEN
_4"=myData$PIEN_4,"PIEN_5"=myData$PIEN_5,"PIEX_1"=myData$PIEX_1,"PIEX_2"=myData$PIEX_2,"PIEX_3"=m
yData$PIEX_3,"PIEX_4"=myData$PIEX_4,"CL_1"=myData$C_1,"CL_2"=myData$C_2,"CL_3"=myData$C_3,"CL_4"=
myData$C_4,"CL_5"=myData$C_5,"VU_1"=myData$V_1,"VU_2"=myData$V_2,"VU_3"=myData$V_3,"VU_4"=myData$
V_4,"AL_1"=myData$TA_1,"AL_2"=myData$TA_2,"AL_3"=myData$TA_3,"AL_4"=myData$TA_4,"AL_5"=myData$TA_
5,"AL_6"=myData$TA_6,"PF_1"=myData$F_1,"PF_2"=myData$F_2,"PF_3"=myData$F_3,"PF_4"=myData$F_4),str
ingsAsFactors=FALSE)
> nrow(FTP) #RESULT: N=767 before listwise deletion
[1] 767
>
> ##LISTWISE DELETION
> #First check what questions are being skipped
> describe(FTP) #Prints stats on each item
FTP

 32  Variables      767  Observations
-------------------------------------------------------------------------------------------------
ID
       n  missing distinct
     767        0      767

lowest : 001AF16 002AF16 003AF16 004AF16 005AF16, highest: 771CS17 772CS17 773CS17 774CS17 775CS1
7
-------------------------------------------------------------------------------------------------
FoP_1
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency     21    57    97   173   208   135    76
Proportion 0.027 0.074 0.126 0.226 0.271 0.176 0.099
-------------------------------------------------------------------------------------------------
FoP_2
```

```
       n  missing distinct 
     766        1        7 

Value          1     2     3     4     5     6     7
Frequency     27    48    92   158   222   145    74
Proportion 0.035 0.063 0.120 0.206 0.290 0.189 0.097
---------------------------------------------------------------------------------------------------
FoP_3 
       n  missing distinct 
     766        1        7 

Value          1     2     3     4     5     6     7
Frequency     12    34    66   142   245   154   113
Proportion 0.016 0.044 0.086 0.185 0.320 0.201 0.148
---------------------------------------------------------------------------------------------------
PIEN_1 
       n  missing distinct 
     767        0        7 

Value          1     2     3     4     5     6     7
Frequency     16    43    75   151   241   160    81
Proportion 0.021 0.056 0.098 0.197 0.314 0.209 0.106
---------------------------------------------------------------------------------------------------
PIEN_2 
       n  missing distinct 
     764        3        7 

Value          1     2     3     4     5     6     7
Frequency     10    26    48    94   160   247   179
Proportion 0.013 0.034 0.063 0.123 0.209 0.323 0.234
---------------------------------------------------------------------------------------------------
PIEN_3 
       n  missing distinct 
     766        1        7 

Value          1     2     3     4     5     6     7
Frequency     13    30    56   103   275   191    98
Proportion 0.017 0.039 0.073 0.134 0.359 0.249 0.128
---------------------------------------------------------------------------------------------------

PIEN_4 
       n  missing distinct 
     764        3        7 

Value          1     2     3     4     5     6     7
Frequency     11    33    50   100   244   207   119
Proportion 0.014 0.043 0.065 0.131 0.319 0.271 0.156
---------------------------------------------------------------------------------------------------
PIEN_5 
       n  missing distinct 
     767        0        7 

Value          1     2     3     4     5     6     7
Frequency     12    31    47    72   141   214   250
Proportion 0.016 0.040 0.061 0.094 0.184 0.279 0.326
---------------------------------------------------------------------------------------------------
PIEX_1 
```

```
       n  missing distinct 
     767        0        7 

Value          1     2     3     4     5     6     7
Frequency     44    67   105   113   140   162   136
Proportion 0.057 0.087 0.137 0.147 0.183 0.211 0.177
---------------------------------------------------------------------------------------------------
PIEX_2 
       n  missing distinct 
     765        2        7 

Value          1     2     3     4     5     6     7
Frequency     15    29    71   100   200   216   134
Proportion 0.020 0.038 0.093 0.131 0.261 0.282 0.175
---------------------------------------------------------------------------------------------------
PIEX_3 
       n  missing distinct 
     767        0        7 

Value          1     2     3     4     5     6     7
Frequency      8    10    19    34    86   163   447
Proportion 0.010 0.013 0.025 0.044 0.112 0.213 0.583
---------------------------------------------------------------------------------------------------
PIEX_4 
       n  missing distinct 
     765        2        7 

Value          1     2     3     4     5     6     7
Frequency     25    54    91   139   217   134   105
Proportion 0.033 0.071 0.119 0.182 0.284 0.175 0.137
---------------------------------------------------------------------------------------------------
CL_1 
       n  missing distinct 
     767        0        7 

Value          1     2     3     4     5     6     7
Frequency     28    55   140   140   133   157   114
Proportion 0.037 0.072 0.183 0.183 0.173 0.205 0.149
---------------------------------------------------------------------------------------------------
CL_2 
       n  missing distinct 
     765        2        7 

Value          1     2     3     4     5     6     7
Frequency     62   114   180   163   129    68    49
Proportion 0.081 0.149 0.235 0.213 0.169 0.089 0.064
---------------------------------------------------------------------------------------------------
CL_3 
       n  missing distinct 
     766        1        7 

Value          1     2     3     4     5     6     7
Frequency    106   138   141   135   118    77    51
Proportion 0.138 0.180 0.184 0.176 0.154 0.101 0.067
---------------------------------------------------------------------------------------------------
CL_4 
       n  missing distinct 
```

```
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     21    86   160   122   134   143   100
Proportion 0.027 0.112 0.209 0.159 0.175 0.187 0.131
----------------------------------------------------------------------------------------------------
CL_5
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     16    61   123   101   105   179   181
Proportion 0.021 0.080 0.161 0.132 0.137 0.234 0.236
----------------------------------------------------------------------------------------------------
VU_1
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     11    23    57    83   179   190   223
Proportion 0.014 0.030 0.074 0.108 0.234 0.248 0.291
----------------------------------------------------------------------------------------------------

VU_2
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     17    23    68    71    90   189   308
Proportion 0.022 0.030 0.089 0.093 0.117 0.247 0.402
----------------------------------------------------------------------------------------------------
VU_3
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency      7    16    38    73   177   227   229
Proportion 0.009 0.021 0.050 0.095 0.231 0.296 0.299
----------------------------------------------------------------------------------------------------
VU_4
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency     12    47    85   176   158   167   122
Proportion 0.016 0.061 0.111 0.229 0.206 0.218 0.159
----------------------------------------------------------------------------------------------------
AL_1
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency     34    55    88    94   148   211   137
Proportion 0.044 0.072 0.115 0.123 0.193 0.275 0.179
----------------------------------------------------------------------------------------------------
AL_2
       n  missing distinct
```

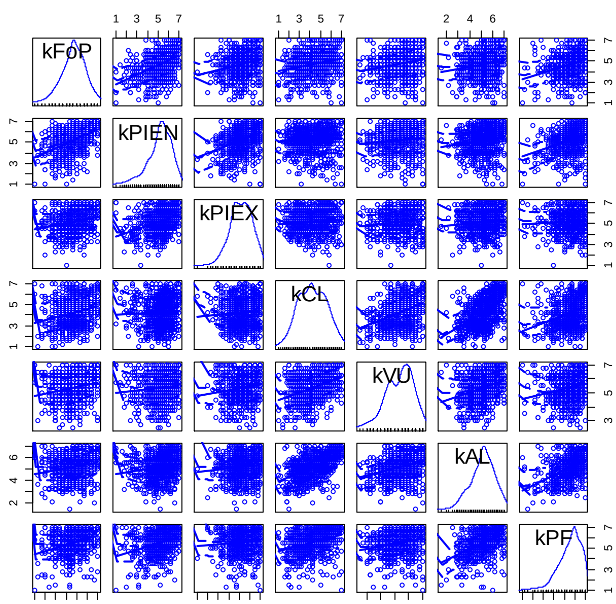
```
     767        0        7

Value          1     2     3     4     5     6     7
Frequency     31    59    91   154   160   191    81
Proportion 0.040 0.077 0.119 0.201 0.209 0.249 0.106
--------------------------------------------------------------------------------------------------
AL_3
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency     27    45   104   167   163   173    88
Proportion 0.035 0.059 0.136 0.218 0.213 0.226 0.115
--------------------------------------------------------------------------------------------------
AL_4
       n  missing distinct
     765        2        7

Value          1     2     3     4     5     6     7
Frequency      4    12    23    54   153   252   267
Proportion 0.005 0.016 0.030 0.071 0.200 0.329 0.349
--------------------------------------------------------------------------------------------------
AL_5
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     10    19    57   137   165   219   159
Proportion 0.013 0.025 0.074 0.179 0.215 0.286 0.208
--------------------------------------------------------------------------------------------------
AL_6
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency      3     9    18    82   196   277   181
Proportion 0.004 0.012 0.023 0.107 0.256 0.362 0.236
--------------------------------------------------------------------------------------------------
PF_1
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     11    17    41    76   158   231   232
Proportion 0.014 0.022 0.054 0.099 0.206 0.302 0.303
--------------------------------------------------------------------------------------------------
PF_2
       n  missing distinct
     766        1        7

Value          1     2     3     4     5     6     7
Frequency     27    36    73   120   170   182   158
Proportion 0.035 0.047 0.095 0.157 0.222 0.238 0.206
--------------------------------------------------------------------------------------------------
PF_3
       n  missing distinct
     767        0        7
```

```
Value          1     2     3     4     5     6     7
Frequency     12    17    40   117   200   215   166
Proportion 0.016 0.022 0.052 0.153 0.261 0.280 0.216
---------------------------------------------------------------------------------------------------
PF_4
       n  missing distinct
     767        0        7

Value          1     2     3     4     5     6     7
Frequency      5    10    15    43    81   193   420
Proportion 0.007 0.013 0.020 0.056 0.106 0.252 0.548
---------------------------------------------------------------------------------------------------
> # n, nmiss, unique, mean, 5,10,25,50,75,90,95th percentiles
> # 5 lowest and 5 highest scores
> # RESULT: Most have 0-2 missing, PIEN_2 and PIEN_4 have 3 missing
>
> FTP <-na.omit(FTP) #listwise delete: all participants who did not answer at least one FTP item
were removed from the data set.
> nrow(FTP) #RESULT: N=746 after listwise deletion
[1] 746
> #RESULT: removed 21 participants with listwise deletion
> #Looked at demographics and which questions were skipped but did not see any patterns
>
> ##DEFINING FACTORS
> FoP <-as.data.frame(cbind('FoP_1'=as.numeric(FTP$FoP_1),'FoP_2'=as.numeric(FTP$FoP_2),'FoP_3'=a
s.numeric(FTP$FoP_3)))
> PIEN <-as.data.frame(cbind('PIEN_1'=as.numeric(FTP$PIEN_1),'PIEN_2'=as.numeric(FTP$PIEN_2),'PIE
N_3'=as.numeric(FTP$PIEN_3),'PIEN_4'=as.numeric(FTP$PIEN_4),'PIEN_5'=as.numeric(FTP$PIEN_5)))
> PIEX <-as.data.frame(cbind('PIEX_1'=as.numeric(FTP$PIEX_1),'PIEX_2'=as.numeric(FTP$PIEX_2),'PIE
X_3'=as.numeric(FTP$PIEX_3),'PIEN_4'=as.numeric(FTP$PIEX_4)))
> CL <-as.data.frame(cbind('CL_1'=as.numeric(FTP$CL_1),'CL_2'=as.numeric(FTP$CL_2),'CL_3'=as.nume
ric(FTP$CL_3),'CL_4'=as.numeric(FTP$CL_4),'CL_5'=as.numeric(FTP$CL_5)))
> VU <-as.data.frame(cbind('VU_1'=as.numeric(FTP$VU_1),'VU_2'=as.numeric(FTP$VU_2),'VU_3'=as.nume
ric(FTP$VU_3),'VU_4'=as.numeric(FTP$VU_4)))
> AL <-as.data.frame(cbind('AL_1'=as.numeric(FTP$AL_1),'AL_2'=as.numeric(FTP$AL_2),'AL_3'=as.nume
ric(FTP$AL_3),'AL_4'=as.numeric(FTP$AL_4),'AL_5'=as.numeric(FTP$AL_5),'AL_6'=as.numeric(FTP$AL_6)
))
> PF <-as.data.frame(cbind('PF_1'=as.numeric(FTP$PF_1),'PF_2'=as.numeric(FTP$PF_2),'PF_3'=as.nume
ric(FTP$PF_3),'PF_4'=as.numeric(FTP$PF_4)))
> ID <-as.data.frame(cbind('ID'=FTP$ID))
>
> ## FACTOR MEANS
> #Means on each factor based on expected factors for each participant
>
> kFoP <- rowMeans(FoP, na.rm = FALSE)   #Effect of Future on Present
> kPIEN <- rowMeans(PIEN, na.rm = FALSE) #Endogenous Perceived Intsrumentality
> kPIEX <- rowMeans(PIEX, na.rm = FALSE) #Exogenous Perceived Instrumentality
> kCL <- rowMeans(CL, na.rm = FALSE)     #Clarity of Future Possible Careers
> kVU <- rowMeans(VU, na.rm = FALSE)     #Value of the Future
> kAL <- rowMeans(AL, na.rm = FALSE)     #Alignment of Ideal and Realistic Future Possible Career
s
> kPF <- rowMeans(PF, na.rm = FALSE)     #Perceptions of Future in Engineering
>
> ## CONTEXT DEPENDENT FACTORS
> # define data set of factor means for each person, including context dependent factors
> FTP.C <- as.data.frame(cbind(kFoP, kPIEN, kPIEX, kCL, kVU, kAL, kPF))
```

```
> nrow(FTP.C) #check should be 746
[1] 746
>
> ## NON CONTEXT DEPENDENT FACTORS
> # defined data set with no context specific factors(FoP, PIEN, PIEX)
> FTP.N <- as.data.frame(cbind(kCL, kVU, kAL, kPF)) #Non-Context Specific FTP factors
> nrow(FTP.N) #check: should be 746
[1] 746
>
> ## NON CONTEXT DEPENDENT FACTORS WITH ACCEPALBLE ALPHAS
> # Removed VU for low alpha
> FTP.N.1 <- as.data.frame(cbind(kCL, kAL, kPF)) #Non-Context Specific FTP factors without V beca
use of low alpha
> nrow(FTP.N.1) #check: should be 746
[1] 746
> #FTP.N.1 is the data set used for the CA
>
> ## CONTEXT DEPENDENT FACTORS WITH ACCEPALBLE ALPHAS
> # Removed VU and PIEX for low alpha
> FTP.C.1 <- as.data.frame(cbind(kFoP, kPIEN, kCL, kAL, kPF)) #Context Specific FTP factors witho
ut V and PIEX because of low alphas
> nrow(FTP.C.1) #check: should be 746
[1] 746
>
> ## CONTEXT DEPENDENT FACTORS WITH ACCEPALBLE ALPHAS
> # Removed VU and PIEX for low alpha
> FTP.CL.AL <- as.data.frame(cbind(kCL, kAL)) #Context Specific FTP factors without V and PIEX be
cause of low alphas
> nrow(FTP.CL.AL) #check: should be 746
[1] 746
>
> ############################## EXAMINING THE DATA #######################
>
> #Print stats for factor means and items
>
> Hmisc::describe(FTP.C.1)
FTP.C.1

 5  Variables      746  Observations
---------------------------------------------------------------------------------------------------
kFoP
       n  missing distinct     Info     Mean      Gmd      .05      .10      .25      .50      .7
5      .90      .95
     746        0       19    0.992    4.705    1.303    2.667    3.000    4.000    4.667    5.58
3    6.000    6.667

Value      1.000000 1.333333 1.666667 2.000000 2.333333 2.666667 3.000000 3.333333 3.666667 4.000
000 4.333333 4.666667 5.000000 5.333333 5.666667 6.000000
Frequency         2        2        7        9        9       18       31       33       48
61       73      103       85       78       69       44
Proportion    0.003    0.003    0.009    0.012    0.012    0.024    0.042    0.044    0.064    0.
082    0.098    0.138    0.114    0.105    0.092    0.059

Value      6.333333 6.666667 7.000000
Frequency        34       14       26
Proportion    0.046    0.019    0.035
---------------------------------------------------------------------------------------------------
```

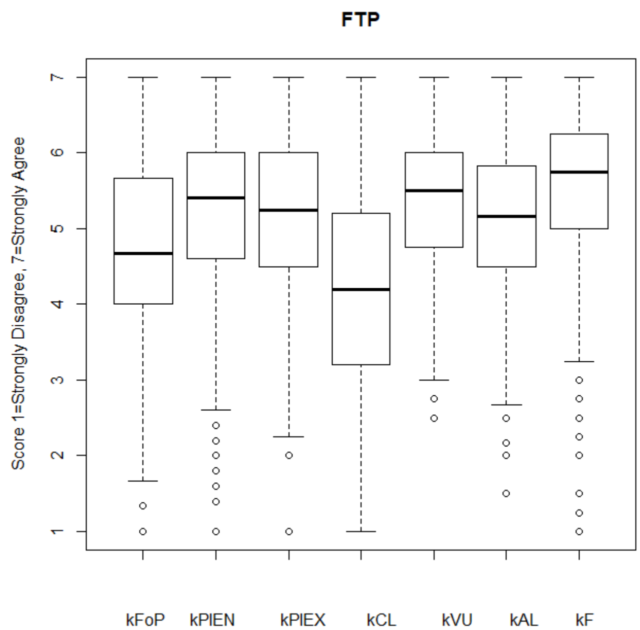
```
kPIEN
       n  missing distinct     Info     Mean      Gmd      .05      .10      .25      .50      .7
5      .90      .95
     746        0       30    0.996    5.183    1.247     2.85     3.80     4.60     5.40     6.0
0     6.60     6.80

lowest : 1.0 1.4 1.6 1.8 2.0, highest: 6.2 6.4 6.6 6.8 7.0
-------------------------------------------------------------------------------------------------
kCL
       n  missing distinct     Info     Mean      Gmd      .05      .10      .25      .50      .7
5      .90      .95
     746        0       31    0.998    4.266    1.529     2.05     2.60     3.20     4.20     5.2
0     6.00     6.40

lowest : 1.0 1.2 1.4 1.6 1.8, highest: 6.2 6.4 6.6 6.8 7.0
-------------------------------------------------------------------------------------------------
kAL
       n  missing distinct     Info     Mean      Gmd      .05      .10      .25      .50      .7
5      .90      .95
     746        0       31    0.997    5.155    1.151    3.333    3.667    4.500    5.167    5.83
3    6.500    6.833

lowest : 1.500000 2.000000 2.166667 2.500000 2.666667, highest: 6.333333 6.500000 6.666667 6.8333
33 7.000000
-------------------------------------------------------------------------------------------------
kPF
       n  missing distinct     Info     Mean      Gmd      .05      .10      .25      .50      .7
5      .90      .95
     746        0       24    0.994    5.534    1.195    3.562    4.000    5.000    5.750    6.25
0    6.750    7.000

lowest : 1.00 1.25 1.50 2.00 2.25, highest: 6.00 6.25 6.50 6.75 7.00
-------------------------------------------------------------------------------------------------
> #the cutoff points for a "high" and "low" score are determined by looking at the factor means
> #RESULT: the cutoff for FoP=4.7, PIEN=5.18, CL=4.27, AL=5.15, PF=5.53
>
> ##ASSUMPTIONS OF NORMLITY
>
> #Evaluate Skew and Kurtosis for each item to check that the assumptions of
> #multivariate normality are not severly violated (skew<|2.0|, kurtosis<7.0)
>
> skew(FoP)
[1] -0.3098926 -0.4228469 -0.4850565
> skew(PIEN)
[1] -0.4970718 -0.9331926 -0.7271104 -0.7486468 -1.0436437
> skew(PIEX)
[1] -0.4032271 -0.7403053 -1.9549376 -0.4057761
> skew(CL)
[1] -0.23916199  0.20927288  0.22437388 -0.07706485 -0.42040108
> skew(VU)
[1] -0.8571888 -1.0860078 -1.0126341 -0.3398186
> skew(AL)
[1] -0.6464020 -0.4385663 -0.3741707 -1.1951644 -0.6578745 -0.8560183
> skew(PF)
[1] -1.0792614 -0.6591477 -0.8128776 -1.8265696
>
> kurtosis(FoP)
```

```
   FoP_1    FoP_2    FoP_3
2.578045 2.730268 2.931885
> kurtosis(PIEN)
  PIEN_1   PIEN_2   PIEN_3   PIEN_4   PIEN_5
2.894167 3.449349 3.429519 3.314812 3.435952
> kurtosis(PIEX)
  PIEX_1   PIEX_2   PIEX_3   PIEN_4
2.134318 3.076919 6.939924 2.546834
> kurtosis(CL)
    CL_1     CL_2     CL_3     CL_4     CL_5
2.133382 2.350273 2.041990 1.933127 1.979800
> kurtosis(VU)
    VU_1     VU_2     VU_3     VU_4
3.210021 3.274057 3.842193 2.408247
> kurtosis(AL)
    AL_1     AL_2     AL_3     AL_4     AL_5     AL_6
2.493612 2.413984 2.483612 4.570070 2.981655 3.934155
> kurtosis(PF)
    PF_1     PF_2     PF_3     PF_4
3.908805 2.754664 3.554496 6.529367
>
> #RESULT: All items are within acceptable range for normality assumptions
>
>
> ##VISUALIZE THE DATA
>
> #prints a scatterplot for visualization of data distribution
> #note that scatterplot matrices are not as good for discrete variables
> windows() #Opens plot in new window
> scatterplotMatrix(FTP.C)
```




```
> #RESULT: distribtions look fairly normal, with a negative skew, particularly PF
>
> #prints boxplot for visualizing data
> #mean and median should be about equal
```

```
> windows()
> boxplot(kFoP,kPIEN,kPIEX,kCL,kVU,kAL,kPF,main="FTP",
+         ylab="Score 1=Strongly Disagree, 7=Strongly Agree", xlab="kFoP      kPIEN           kPI
EX          kCL            kVU          kAL          kF")
```




```
> #RESULT: The line (median) falls in about the middle for all factors
> #RESULT: CL has a particularly wide distribution
> ################################## CFA ##################################
>
> ## CHRONBACH'S ALPHA
> # First, check chronbach's alphas for each of the factors (acceptable >0.7)
> psych::alpha(FoP)

Reliability analysis
Call: psych::alpha(x = FoP)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
      0.72      0.72    0.63      0.46 2.5 0.018  4.7 1.2     0.43

 lower alpha upper     95% confidence boundaries
0.68 0.72 0.75

 Reliability if an item is dropped:
      raw_alpha std.alpha G6(smc) average_r S/N alpha se var.r med.r
FoP_1      0.60      0.60    0.43      0.43 1.5    0.029    NA  0.43
FoP_2      0.69      0.69    0.53      0.53 2.2    0.023    NA  0.53
FoP_3      0.59      0.59    0.42      0.42 1.4    0.030    NA  0.42

 Item statistics
        n raw.r std.r r.cor r.drop mean  sd
FoP_1 746  0.81  0.81  0.66   0.56  4.6 1.5
FoP_2 746  0.77  0.77  0.57   0.48  4.6 1.5
FoP_3 746  0.81  0.82  0.67   0.57  5.0 1.4

Non missing response frequency for each item
```

```
         1    2    3    4    5    6    7 miss
FoP_1 0.03 0.07 0.13 0.23 0.27 0.18 0.10    0
FoP_2 0.03 0.06 0.12 0.21 0.29 0.18 0.10    0
FoP_3 0.01 0.04 0.09 0.18 0.32 0.20 0.15    0
> psych::alpha(PIEN)

Reliability analysis
Call: psych::alpha(x = PIEN)

  raw_alpha std.alpha G6(smc) average_r S/N    ase mean  sd median_r
      0.87      0.87    0.85      0.57 6.6 0.0078  5.2 1.1     0.57

 lower alpha upper     95% confidence boundaries
0.85 0.87 0.88

 Reliability if an item is dropped:
       raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
PIEN_1      0.87      0.87    0.84      0.62 6.6   0.0080 0.0051  0.61
PIEN_2      0.84      0.84    0.81      0.57 5.3   0.0098 0.0106  0.55
PIEN_3      0.83      0.83    0.80      0.55 4.8   0.0104 0.0104  0.57
PIEN_4      0.81      0.81    0.77      0.51 4.2   0.0115 0.0054  0.53
PIEN_5      0.85      0.85    0.82      0.59 5.7   0.0092 0.0125  0.58

 Item statistics
         n raw.r std.r r.cor r.drop mean  sd
PIEN_1 746  0.73  0.73  0.61   0.57  4.8 1.4
PIEN_2 746  0.81  0.81  0.74   0.69  5.4 1.4
PIEN_3 746  0.84  0.84  0.80   0.74  5.0 1.3
PIEN_4 746  0.89  0.89  0.88   0.81  5.1 1.4
PIEN_5 746  0.79  0.78  0.70   0.65  5.5 1.5

Non missing response frequency for each item
          1    2    3    4    5    6    7 miss
PIEN_1 0.02 0.06 0.10 0.20 0.32 0.21 0.10    0
PIEN_2 0.01 0.03 0.06 0.12 0.21 0.33 0.23    0
PIEN_3 0.01 0.04 0.08 0.13 0.36 0.25 0.13    0
PIEN_4 0.01 0.04 0.07 0.13 0.32 0.27 0.16    0
PIEN_5 0.01 0.04 0.06 0.09 0.18 0.28 0.33    0
> psych::alpha(PIEX)

Reliability analysis
Call: psych::alpha(x = PIEX)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean sd median_r
      0.63      0.63    0.57       0.3 1.7 0.022  5.2  1      0.3

 lower alpha upper     95% confidence boundaries
0.58 0.63 0.67

 Reliability if an item is dropped:
       raw_alpha std.alpha G6(smc) average_r  S/N alpha se  var.r med.r
PIEX_1      0.59      0.59    0.50      0.32 1.43    0.025 0.0134  0.30
PIEX_2      0.52      0.53    0.43      0.28 1.14    0.029 0.0020  0.30
PIEX_3      0.61      0.62    0.53      0.35 1.63    0.025 0.0069  0.30
PIEN_4      0.49      0.50    0.40      0.25 0.99    0.031 0.0022  0.22

 Item statistics
```

```
        n raw.r std.r r.cor r.drop mean  sd
PIEX_1 746  0.71  0.66  0.47   0.38  4.7 1.8
PIEX_2 746  0.71  0.72  0.58   0.46  5.1 1.5
PIEX_3 746  0.58  0.63  0.41   0.33  6.2 1.2
PIEN_4 746  0.75  0.74  0.63   0.49  4.7 1.6

Non missing response frequency for each item
          1    2    3    4    5    6    7 miss
PIEX_1 0.06 0.09 0.13 0.15 0.18 0.21 0.17    0
PIEX_2 0.02 0.04 0.09 0.13 0.26 0.29 0.17    0
PIEX_3 0.01 0.01 0.03 0.04 0.11 0.22 0.59    0
PIEN_4 0.03 0.07 0.12 0.18 0.29 0.18 0.14    0
> psych::alpha(CL)

Reliability analysis
Call: psych::alpha(x = CL)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
      0.85      0.85    0.82      0.52 5.5 0.009  4.3 1.3     0.52

 lower alpha upper     95% confidence boundaries
0.83 0.85 0.86

 Reliability if an item is dropped:
     raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
CL_1      0.81      0.81    0.77      0.52 4.3    0.011 0.0031  0.52
CL_2      0.82      0.82    0.78      0.54 4.7    0.011 0.0044  0.53
CL_3      0.82      0.82    0.79      0.54 4.7    0.010 0.0058  0.56
CL_4      0.80      0.80    0.75      0.49 3.9    0.012 0.0030  0.48
CL_5      0.81      0.82    0.78      0.53 4.4    0.011 0.0042  0.52

 Item statistics
       n raw.r std.r r.cor r.drop mean  sd
CL_1 746  0.79  0.79  0.73   0.67  4.6 1.7
CL_2 746  0.76  0.76  0.68   0.62  3.8 1.6
CL_3 746  0.77  0.76  0.67   0.62  3.6 1.8
CL_4 746  0.83  0.83  0.79   0.72  4.4 1.7
CL_5 746  0.79  0.78  0.71   0.65  4.9 1.7

Non missing response frequency for each item
        1    2    3    4    5    6    7 miss
CL_1 0.04 0.07 0.18 0.18 0.18 0.21 0.15    0
CL_2 0.08 0.15 0.24 0.21 0.17 0.09 0.07    0
CL_3 0.14 0.18 0.18 0.17 0.15 0.10 0.07    0
CL_4 0.03 0.12 0.21 0.16 0.18 0.19 0.13    0
CL_5 0.02 0.08 0.16 0.13 0.14 0.24 0.24    0
> psych::alpha(VU)

Reliability analysis
Call: psych::alpha(x = VU)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean   sd median_r
      0.54      0.56    0.61      0.24 1.3 0.028  5.4 0.96     0.17

 lower alpha upper     95% confidence boundaries
0.48 0.54 0.59
```

```
 Reliability if an item is dropped:
     raw_alpha std.alpha G6(smc) average_r  S/N alpha se var.r med.r
VU_1      0.26      0.27    0.22      0.11 0.38    0.047 0.016  0.12
VU_2      0.59      0.60    0.65      0.34 1.52    0.028 0.147  0.12
VU_3      0.26      0.26    0.21      0.11 0.35    0.047 0.014  0.11
VU_4      0.66      0.68    0.68      0.41 2.09    0.023 0.102  0.24

 Item statistics
       n raw.r std.r r.cor r.drop mean  sd
VU_1 746  0.79  0.80  0.84  0.548  5.4 1.5
VU_2 746  0.58  0.55  0.24  0.190  5.6 1.6
VU_3 746  0.79  0.81  0.85  0.583  5.6 1.3
VU_4 746  0.47  0.46  0.11  0.087  4.8 1.5

Non missing response frequency for each item
        1    2    3    4    5    6    7 miss
VU_1 0.01 0.03 0.07 0.11 0.24 0.25 0.29    0
VU_2 0.02 0.03 0.08 0.09 0.12 0.25 0.40    0
VU_3 0.01 0.02 0.05 0.09 0.23 0.30 0.30    0
VU_4 0.02 0.06 0.11 0.23 0.21 0.22 0.16    0
> psych::alpha(AL)

Reliability analysis
Call: psych::alpha(x = AL)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean sd median_r
       0.8       0.8    0.79       0.4 4.1 0.011  5.2  1     0.39

 lower alpha upper     95% confidence boundaries
0.78 0.8 0.82

 Reliability if an item is dropped:
     raw_alpha std.alpha G6(smc) average_r S/N alpha se  var.r med.r
AL_1      0.77      0.77    0.75      0.40 3.3    0.013 0.0090  0.39
AL_2      0.74      0.74    0.71      0.37 2.9    0.015 0.0040  0.34
AL_3      0.76      0.76    0.73      0.39 3.2    0.014 0.0063  0.37
AL_4      0.79      0.79    0.77      0.43 3.8    0.012 0.0117  0.40
AL_5      0.79      0.78    0.77      0.42 3.6    0.012 0.0142  0.38
AL_6      0.78      0.78    0.76      0.41 3.5    0.012 0.0144  0.37

 Item statistics
       n raw.r std.r r.cor r.drop mean  sd
AL_1 746  0.75  0.72  0.65   0.59  4.9 1.7
AL_2 746  0.82  0.79  0.77   0.70  4.6 1.6
AL_3 746  0.77  0.74  0.69   0.62  4.7 1.5
AL_4 746  0.61  0.64  0.53   0.46  5.8 1.2
AL_5 746  0.66  0.67  0.56   0.50  5.2 1.4
AL_6 746  0.64  0.68  0.59   0.51  5.6 1.1

Non missing response frequency for each item
        1    2    3    4    5    6    7 miss
AL_1 0.04 0.07 0.11 0.12 0.20 0.28 0.18    0
AL_2 0.04 0.08 0.12 0.20 0.21 0.25 0.10    0
AL_3 0.03 0.06 0.14 0.22 0.21 0.23 0.11    0
AL_4 0.00 0.01 0.03 0.07 0.20 0.33 0.35    0
AL_5 0.01 0.02 0.07 0.18 0.22 0.29 0.21    0
AL_6 0.00 0.01 0.02 0.10 0.26 0.37 0.24    0
```

```
> psych::alpha(PF)

Reliability analysis
Call: psych::alpha(x = PF)

  raw_alpha std.alpha G6(smc) average_r S/N   ase mean  sd median_r
       0.8       0.8    0.76       0.5 4.1 0.012  5.5 1.1     0.51

 lower alpha upper     95% confidence boundaries
0.77 0.8 0.82

 Reliability if an item is dropped:
     raw_alpha std.alpha G6(smc) average_r S/N alpha se   var.r med.r
PF_1      0.76      0.77    0.70      0.53 3.4    0.015 0.00116  0.51
PF_2      0.76      0.76    0.68      0.52 3.2    0.015 0.00065  0.51
PF_3      0.73      0.74    0.66      0.49 2.8    0.017 0.00769  0.49
PF_4      0.73      0.74    0.66      0.48 2.8    0.017 0.00588  0.51

 Item statistics
       n raw.r std.r r.cor r.drop mean  sd
PF_1 746  0.76  0.77  0.65   0.57  5.6 1.4
PF_2 746  0.80  0.78  0.68   0.59  5.0 1.6
PF_3 746  0.81  0.81  0.72   0.64  5.3 1.4
PF_4 746  0.79  0.81  0.73   0.65  6.2 1.2

Non missing response frequency for each item
        1    2    3    4    5    6    7 miss
PF_1 0.01 0.02 0.05 0.10 0.21 0.31 0.30    0
PF_2 0.03 0.05 0.09 0.16 0.22 0.24 0.21    0
PF_3 0.02 0.02 0.05 0.15 0.26 0.28 0.21    0
PF_4 0.01 0.01 0.02 0.05 0.11 0.25 0.55    0
> #Results reported as raw alpha, or the alpha based on covariences
> #RESULT: FoP: 0.71,  PIEN: 0.87, PIEX: 0.63, CL: 0.85, VU: 0.54,  AL: 0.8, PF: 0.8
> #RESULT: alphas for PIEX AND VU are below 0.7
>
> # Check covariance matrix to determine if PIEX and VU below 0.7 is acceptable
> FTP.Cov <-cov(FTP.C) #Covariance Matrix
> print(FTP.Cov) #want max covariance to be less than the minimum alpha
           kFoP      kPIEN      kPIEX        kCL       kVU       kAL
kFoP  1.3521381 0.59207994 0.26958514 0.35869442 0.2196694 0.2063468
kPIEN 0.5920799 1.28737377 0.42513585 0.06548234 0.1163829 0.1885630
kPIEX 0.2695851 0.42513585 1.08783321 0.11443781 0.1436627 0.1124331
kCL   0.3586944 0.06548234 0.11443781 1.77887543 0.4623704 0.6723767
kVU   0.2196694 0.11638295 0.14366273 0.46237041 0.9161205 0.2849756
kAL   0.2063468 0.18856295 0.11243313 0.67237670 0.2849756 1.0374808
kPF   0.3875248 0.40783310 0.07311253 0.46172859 0.2189719 0.5314376
             kPF
kFoP  0.38752482
kPIEN 0.40783310
kPIEX 0.07311253
kCL   0.46172859
kVU   0.21897188
kAL   0.53143762
kPF   1.19652644
> #RESULT: minimum alpha is VU, 0.54
> #RESULT: covariances are not all <0.54
> #RESULT: remove VU and PIEX from further analysis.
```

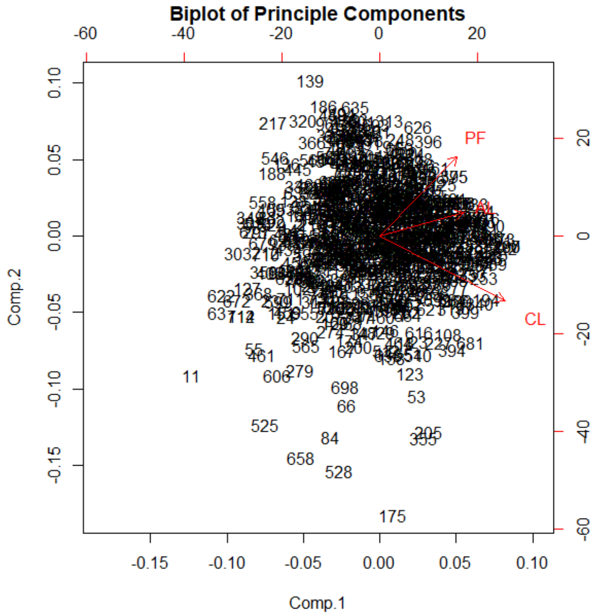
```
>
> #Check covariance matrix with PIEX and VU removed
> FTP.Cov.1 <-cov(FTP.C.1) #Covariance Matrix without VU and PIEX
> print(FTP.Cov.1) #want max covariance to be less than the minimum alpha
           kFoP      kPIEN        kCL       kAL       kPF
kFoP  1.3521381 0.59207994 0.35869442 0.2063468 0.3875248
kPIEN 0.5920799 1.28737377 0.06548234 0.1885630 0.4078331
kCL   0.3586944 0.06548234 1.77887543 0.6723767 0.4617286
kAL   0.2063468 0.18856295 0.67237670 1.0374808 0.5314376
kPF   0.3875248 0.40783310 0.46172859 0.5314376 1.1965264
> #RESULT: lowest alpha is FOP at 0.72
> #RESULT: Covariances are all below 0.72;
> #RESULT: highest covariance is 0.67 wich also is acceptable for the 0.7 rule of thumb
>
> ## CFA FOR EXPECTED FACTORS
> #Measuring how well the model (or the expected factors) fits with the data
> #Create model of factors for CFA of usable factors (high alphas)
> FTP.model <-'FoP =~ FoP_1 + FoP_2 + FoP_3
+ PIEN =~ PIEN_1 + PIEN_2 + PIEN_3 + PIEN_4 + PIEN_5
+ CL =~ CL_1 + CL_2 + CL_3 + CL_4 + CL_5
+ AL =~ AL_1 + AL_2 +AL_3 + AL_4 + AL_5 + AL_6
+ PF =~ PF_1 + PF_2 + PF_3 + PF_4'
>
>
> #Print CFA Summary
> FTP.fit <- cfa(FTP.model, data=FTP)
> summary(FTP.fit, standardized=TRUE, fit.measures=TRUE,rsquare=TRUE)
lavaan (0.5-23.1097) converged normally after  48 iterations

  Number of observations                           746

  Estimator                                         ML
  Minimum Function Test Statistic              975.029
  Degrees of freedom                               220
  P-value (Chi-square)                           0.000

Model test baseline model:

  Minimum Function Test Statistic             7409.577
  Degrees of freedom                               253
  P-value                                        0.000

User model versus baseline model:

  Comparative Fit Index (CFI)                    0.894
  Tucker-Lewis Index (TLI)                       0.879

Loglikelihood and Information Criteria:

  Loglikelihood user model (H0)                     NA
  Loglikelihood unrestricted model (H1)             NA

  Number of free parameters                         56
  Akaike (AIC)                                      NA
  Bayesian (BIC)                                    NA

Root Mean Square Error of Approximation:
```

```
  RMSEA                                          0.068
  90 Percent confidence interval          0.064  0.072
  P-value RMSEA <= 0.05                          0.000

Standardized Root Mean Square Residual:

  SRMR                                           0.066

Parameter Estimates:

  Information                                 Expected
  Standard Errors                             Standard

Latent Variables:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  FoP =~
    FoP_1             1.000                               1.032    0.696
    FoP_2             0.913    0.068   13.381    0.000    0.942    0.633
    FoP_3             0.958    0.068   14.160    0.000    0.989    0.708
  PIEN =~
    PIEN_1            1.000                               0.882    0.624
    PIEN_2            1.185    0.071   16.640    0.000    1.045    0.742
    PIEN_3            1.255    0.070   17.970    0.000    1.107    0.828
    PIEN_4            1.384    0.074   18.761    0.000    1.220    0.893
    PIEN_5            1.167    0.074   15.716    0.000    1.029    0.688
  CL =~
    CL_1              1.000                               1.272    0.766
    CL_2              0.829    0.048   17.208    0.000    1.053    0.653
    CL_3              0.913    0.053   17.146    0.000    1.161    0.651
    CL_4              1.055    0.050   21.103    0.000    1.342    0.797
    CL_5              1.015    0.051   19.776    0.000    1.291    0.746
  AL =~
    AL_1              1.000                               1.112    0.657
    AL_2              1.097    0.065   16.834    0.000    1.219    0.766
    AL_3              0.963    0.062   15.655    0.000    1.070    0.693
    AL_4              0.569    0.045   12.661    0.000    0.633    0.538
    AL_5              0.744    0.054   13.749    0.000    0.827    0.592
    AL_6              0.605    0.043   13.986    0.000    0.673    0.604
  PF =~
    PF_1              1.000                               0.980    0.710
    PF_2              1.093    0.069   15.866    0.000    1.071    0.670
    PF_3              1.015    0.059   17.068    0.000    0.995    0.733
    PF_4              0.880    0.052   17.009    0.000    0.862    0.729

Covariances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
  FoP ~~
    PIEN              0.513    0.055    9.271    0.000    0.564    0.564
    CL                0.379    0.065    5.789    0.000    0.289    0.289
    AL                0.248    0.057    4.343    0.000    0.216    0.216
    PF                0.407    0.055    7.346    0.000    0.402    0.402
  PIEN ~~
    CL                0.055    0.047    1.161    0.246    0.049    0.049
    AL                0.161    0.043    3.711    0.000    0.164    0.164
    PF                0.333    0.044    7.587    0.000    0.386    0.386
  CL ~~
```

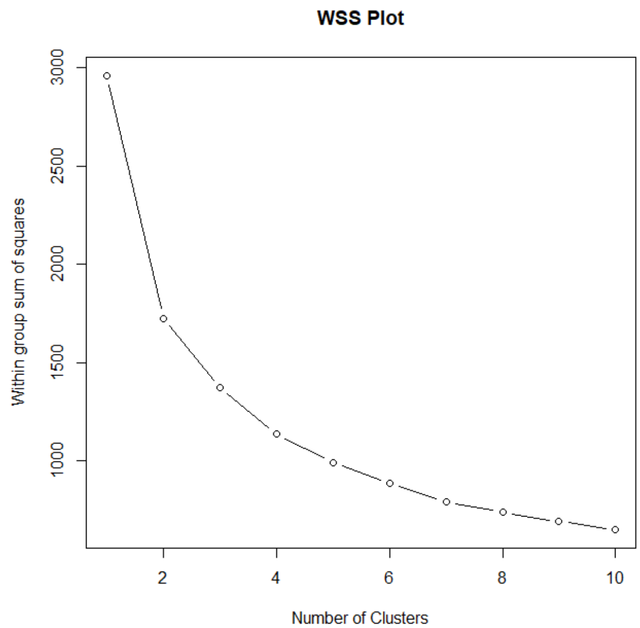
```
    AL                0.835    0.082   10.211    0.000    0.591    0.591
    PF                0.487    0.062    7.810    0.000    0.391    0.391
  AL ~~
    PF                0.623    0.065    9.640    0.000    0.572    0.572

Variances:
                   Estimate  Std.Err  z-value  P(>|z|)   Std.lv  Std.all
   .FoP_1             1.133    0.085   13.271    0.000    1.133    0.516
   .FoP_2             1.324    0.088   15.060    0.000    1.324    0.599
   .FoP_3             0.972    0.076   12.856    0.000    0.972    0.499
   .PIEN_1            1.218    0.068   17.960    0.000    1.218    0.610
   .PIEN_2            0.891    0.053   16.659    0.000    0.891    0.449
   .PIEN_3            0.562    0.039   14.402    0.000    0.562    0.314
   .PIEN_4            0.376    0.035   10.715    0.000    0.376    0.202
   .PIEN_5            1.178    0.068   17.391    0.000    1.178    0.527
   .CL_1              1.142    0.077   14.905    0.000    1.142    0.414
   .CL_2              1.491    0.088   17.026    0.000    1.491    0.573
   .CL_3              1.832    0.107   17.054    0.000    1.832    0.576
   .CL_4              1.035    0.074   13.896    0.000    1.035    0.365
   .CL_5              1.329    0.086   15.422    0.000    1.329    0.444
   .AL_1              1.624    0.098   16.530    0.000    1.624    0.568
   .AL_2              1.048    0.074   14.097    0.000    1.048    0.413
   .AL_3              1.238    0.078   15.917    0.000    1.238    0.519
   .AL_4              0.984    0.055   17.836    0.000    0.984    0.711
   .AL_5              1.270    0.073   17.353    0.000    1.270    0.650
   .AL_6              0.790    0.046   17.224    0.000    0.790    0.636
   .PF_1              0.945    0.063   15.062    0.000    0.945    0.496
   .PF_2              1.407    0.088   15.920    0.000    1.407    0.551
   .PF_3              0.854    0.059   14.453    0.000    0.854    0.463
   .PF_4              0.654    0.045   14.549    0.000    0.654    0.468
    FoP               1.065    0.116    9.212    0.000    1.000    1.000
    PIEN              0.778    0.086    9.090    0.000    1.000    1.000
    CL                1.617    0.139   11.645    0.000    1.000    1.000
    AL                1.236    0.132    9.357    0.000    1.000    1.000
    PF                0.960    0.094   10.190    0.000    1.000    1.000

R-Square:
                   Estimate
    FoP_1             0.484
    FoP_2             0.401
    FoP_3             0.501
    PIEN_1            0.390
    PIEN_2            0.551
    PIEN_3            0.686
    PIEN_4            0.798
    PIEN_5            0.473
    CL_1              0.586
    CL_2              0.427
    CL_3              0.424
    CL_4              0.635
    CL_5              0.556
    AL_1              0.432
    AL_2              0.587
    AL_3              0.481
    AL_4              0.289
    AL_5              0.350
    AL_6              0.364
```

```
    PF_1              0.504
    PF_2              0.449
    PF_3              0.537
    PF_4              0.532

> #CFI and TLI <0.95
> #RMSEA andSRMR <0.08
> #Latent Variable, Std.all "loadings" >0.5, Std.all is the same scale as you would expect in an
EFA
> #Don't want error variances, "Variances, Std.all" to be negative
>
> #RESULT: All  minimum requirements are met (CFI=0.895, TLI=0.879, SRMR=0.066, RMSEA=0.068)
> #R-Square shows what amount of variance is being accounted for, so AL_4 accounts for 28.8% of v
ariances
>
> #create a one factor model to compare for relative fit
> comparative.model <-'computer=~FoP_1 + FoP_2 + FoP_3+PIEN_1 + PIEN_2 + PIEN_3 + PIEN_4 + PIEN_5
+ CL_1 + CL_2 + CL_3 + CL_4 + CL_5 + AL_1 + AL_2 +AL_3 + AL_4 + AL_5 + AL_6 + PF_1 + PF_2 + PF_3
+ PF_4'
> compare.fit <- cfa(comparative.model, data=FTP)
>
> fitMeasures(FTP.fit)
               npar                fmin               chisq 
             56.000               0.654             975.029 
                 df              pvalue      baseline.chisq 
            220.000               0.000            7409.577 
        baseline.df     baseline.pvalue                 cfi 
            253.000               0.000               0.894 
                tli                nnfi                 rfi 
              0.879               0.879               0.849 
                nfi                pnfi                 ifi 
              0.868               0.755               0.895 
                rni                logl   unrestricted.logl 
              0.894                  NA                  NA 
                aic                 bic              ntotal 
                 NA                  NA             746.000 
               bic2               rmsea      rmsea.ci.lower 
                 NA               0.068               0.064 
     rmsea.ci.upper        rmsea.pvalue                 rmr 
              0.072               0.000               0.138 
         rmr_nomean                srmr        srmr_bentler 
              0.138               0.066               0.066 
srmr_bentler_nomean         srmr_bollen  srmr_bollen_nomean 
              0.066               0.066               0.066 
         srmr_mplus   srmr_mplus_nomean               cn_05 
              0.066               0.066             196.562 
              cn_01                 gfi                agfi 
            208.892               0.889               0.861 
               pgfi                 mfi                ecvi 
              0.709               0.603               1.457 
> fitMeasures(compare.fit)
               npar                fmin               chisq 
             46.000               2.780            4147.857 
                 df              pvalue      baseline.chisq 
            230.000               0.000            7409.577 
        baseline.df     baseline.pvalue                 cfi 
            253.000               0.000               0.453 
```

```
                 tli                nnfi                 rfi 
               0.398               0.398               0.384 
                 nfi                pnfi                 ifi 
               0.440               0.400               0.454 
                 rni                logl   unrestricted.logl 
               0.453                  NA                  NA 
                 aic                 bic              ntotal 
                  NA                  NA             746.000 
                bic2               rmsea      rmsea.ci.lower 
                  NA               0.151               0.147 
      rmsea.ci.upper        rmsea.pvalue                 rmr 
               0.155               0.000               0.320 
          rmr_nomean                srmr        srmr_bentler 
               0.320               0.146               0.146 
srmr_bentler_nomean         srmr_bollen  srmr_bollen_nomean 
               0.146               0.146               0.146 
          srmr_mplus   srmr_mplus_nomean               cn_05 
               0.146               0.146              48.909 
               cn_01                 gfi                agfi 
              51.865               0.562               0.474 
                pgfi                 mfi                ecvi 
               0.468               0.072               5.683 
> #RESULT: The proposed model (FTP.fit) is clearly better than the one factor model. The one fact
or model has a chi squared value 3000 greater with only 10 DF greater
> #RESULT: The RMSEA (and SRMR) is much lower in FTP.fit. CFI and TLI are both larger--all indica
ting a better fit with FTP.fit
> 
> #For Future Use (looking at survey development)
> #modindices(FTP.fit,sort.=TRUE, minimum.value=30.00)  #~~shows when two items are very siliar t
o one another, and =~shows when an item is cross-correlated between factors.
> 
> ######################### CLUSTER ANALYSIS ###########################
> 
> ## DEFINE VARIABLES
> DATASET <-as.data.frame(cbind(ID, FTP.N.1, stringsAsFactors=FALSE)) #define data set being used 
to cluster
> #RESULT: use FTP.N.1 and ID
> #Cluster Data by non-context dependent factors because of the wide cariety of contexts in the d
ata
> #View(data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF))
> 
> ## PRINCIPLE COMPONENTS
> #describes principle components (pc) to have a better understanding of the components on the cl
uster plot.
> pc <- princomp(data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF)) #principle compo
nent analysis to get principle component vectors
> #points grouped close together have similar properties, and vectors pointing in the same dircat
ion correspond to variables with smilar meaning
> windows()
> biplot(pc,main="Biplot of Principle Components") #RESULT: No obvious clusters, still want to us
e cluster analysis to get a meaningful description of participants
```

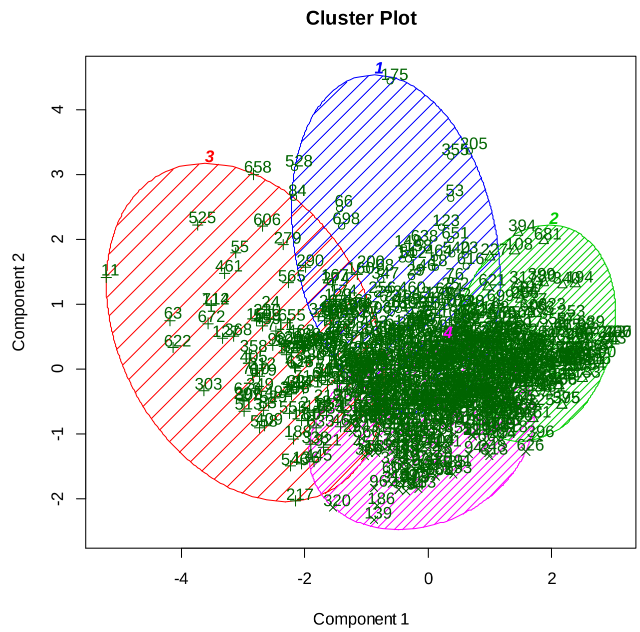



```
> #RESULT: the plot gives more meaning to the cluster plots in where the clusters lay
>
> ## WSS
> #Create a within sum of squares function to use to determine the best number of clusters
>
> sumwss<-vector(mode="numeric",10)
> for(i in 1:100){
+   set.seed(i)
+   wss <- (nrow(data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF))-1)*sum(apply(FTP
.N, 2, var))#set the value of wss[1] as we will run a for loop to set the rest of the values (ie
sum over within sum of squares)
+   for (i in 1:10) wss[i] <- sum(kmeans(data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASE
T$kPF),centers=i)$withinss)
+   sumwss<-sumwss+wss
+   #plot(1:15,wss,type="b",xlab="Number of Clusters", ylab="Within group sum of squares") #plot
the screeplot with x and y titles
+ }
> sumwss<-sumwss/101 #divide by 101 to get the average of running over
>
> windows()
> plot(1:10,sumwss,main="WSS Plot",type="b",xlab="Number of Clusters", ylab="Within group sum of
squares") #plot the screeplot with x and y titles
```



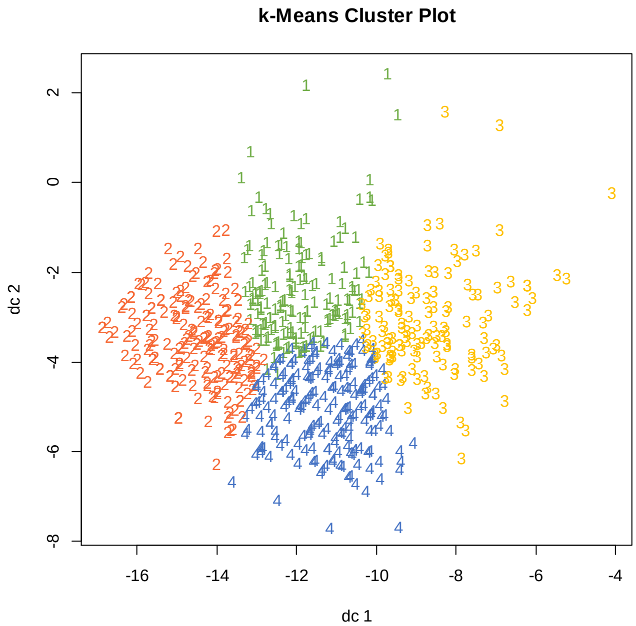

```
> #RESULT: There is no obvious elbow.
> #RESULT: 2 is the most prominant, but 2 groups is not informative for the RQ
> #RESULT: There is a slight elbow at 4. Previous results indicate k=3, but there is more of a ch
ange at k=4 than there is at 3 or 5 and above
>
> K <-4 #define number of clusters
> #RESULT: use K=4 clusters as indicated by wss plot

> ###########################K MEANS#######################
> FTP.kmeans <- kmeans(data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF),K,iter.max
= 500,nstart=100) #run kmeans cluster analysis for k=K, for 100 random sets
>
> #Get cluster means & lengths for k=K
> aggregate (data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF),by=list(FTP.kmeans$cl
uster),FUN=mean)
  Group.1       CL       AL       PF
1       1 4.904545 4.929924 5.042614
2       2 5.658095 6.069841 6.402381
3       3 2.909220 3.874704 4.221631
4       4 3.293151 5.282344 5.939498
> aggregate (data.frame('CL'=DATASET$kCL,'AL'=DATASET$kAL,'PF'=DATASET$kPF),by=list(FTP.kmeans$cl
uster), FUN=length)
  Group.1  CL  AL  PF
1       1 176 176 176
2       2 210 210 210
3       3 141 141 141
4       4 219 219 219
> aggregate (FTP.C.1,by=list(FTP.kmeans$cluster),FUN=mean) #include means for FoP and PIEN
  Group.1     kFoP    kPIEN      kCL      kAL      kPF
1       1 4.547348 4.830682 4.904545 4.929924 5.042614
2       2 5.173016 5.524762 5.658095 6.069841 6.402381
3       3 4.264775 4.809929 2.909220 3.874704 4.221631
4       4 4.666667 5.377169 3.293151 5.282344 5.939498
>
```

```
> #RESULT: Group 1= WAFFLE    Group 2= SUGAR      Group 3= NEW        Group 4= CAKE
> #RESULT: high CL low AL     high CL high AL     low CL low AL       low CL high AL
> #RESULT: N=176              N=210               N=141               N=219
>
> #Data set with cluster assignment
> FTP2 <- data.frame(DATASET,'Cluster'=FTP.kmeans$cluster)
>
> #Plotting Solution
> windows()
> clusplot(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF), FTP.kmeans$cluster,main="Cluster Plot",c
olor=TRUE,shade=TRUE, labels=2, lines=0)
```



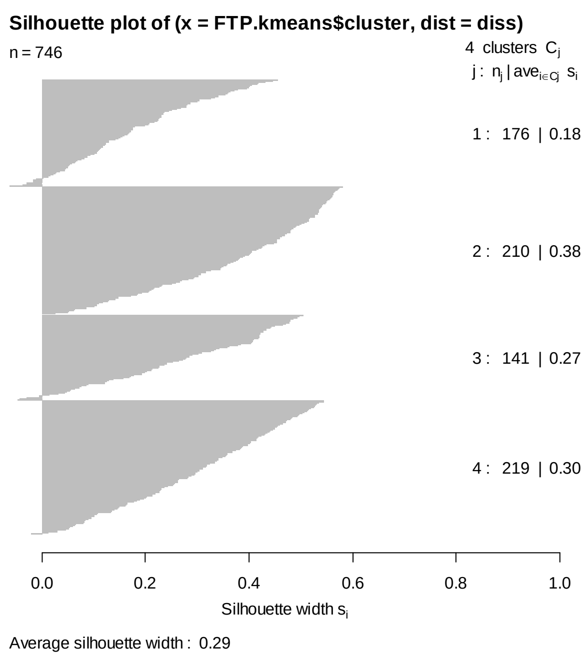
These two components explain 84.91 % of the point variability.

```
>
> vcol<-c("#70ad47","#f66733","#ffc000","#4472c4") #Set colors for clusters to match dissertation
graphcis
>
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.kmeans$cluster,main="k-Means Clust
er Plot",col=vcol[FTP.kmeans$cluster])
```



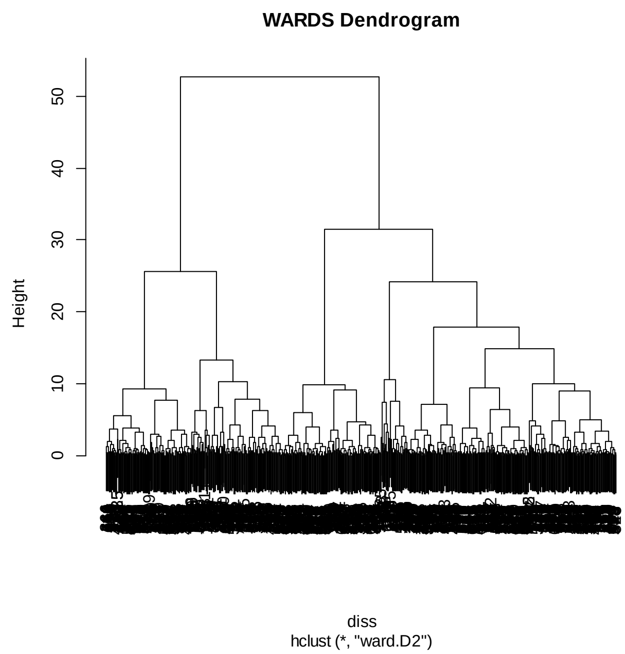

```
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #Outputs a table with pvalue for each pair of clusters
> pairwise.t.test(FTP2$kPF,FTP.kmeans$cluster,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  FTP2$kPF and FTP.kmeans$cluster

  1       2       3
2 < 2e-16 -       -
3 < 2e-16 < 2e-16 -
4 < 2e-16 2.2e-10 < 2e-16

P value adjustment method: none
> pairwise.t.test(FTP2$kCL,FTP.kmeans$cluster,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  FTP2$kCL and FTP.kmeans$cluster

  1       2       3
2 < 2e-16 -       -
3 < 2e-16 < 2e-16 -
4 < 2e-16 < 2e-16 8.3e-07

P value adjustment method: none
> pairwise.t.test(FTP2$kAL,FTP.kmeans$cluster,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  FTP2$kAL and FTP.kmeans$cluster

  1       2       3
2 < 2e-16 -       -
```

```
3 < 2e-16 < 2e-16 -
4 5.8e-07 < 2e-16 < 2e-16

P value adjustment method: none
> #RESULT: All p values p<0.001, showing significant differences between the clusters for each fa
ctor mean
>
> #test the fit of the clusters to the data
>
> ## Silhouette
> #Find the silhouette (indicates if good structure to the clusters and "belonging" of data to cl
usters they're in)
> #.71-1.0 is strong, .51-.7 reasonable, .26-.5 weak, <.25 no substantial structure
>
> diss<-dist(DATASET, method="euclidean")
Warning message:
In dist(DATASET, method = "euclidean") : NAs introduced by coercion
> windows()
> plot(silhouette(FTP.kmeans$cluster,diss))
```

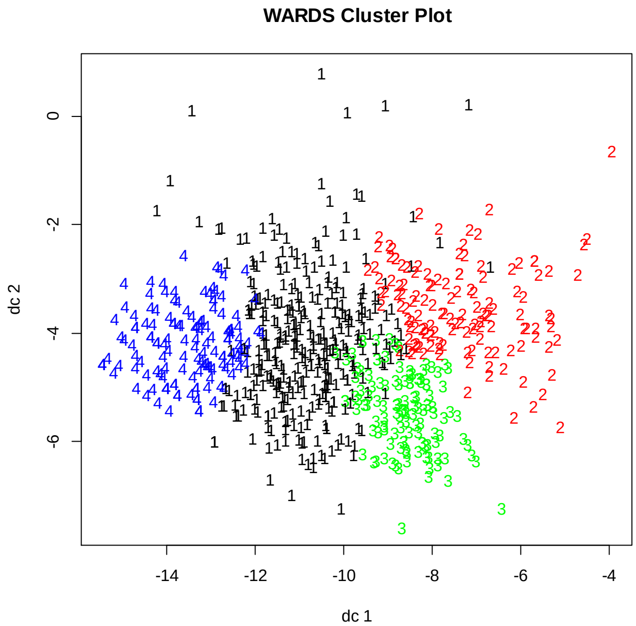



```
> #weak, indicates that WAFFLE (group 3) may be unsubstantial
>
> ##Print an excel spreadsheet with participant ID, factor means, and cluster
> FTP.kmeans.cluster <- data.frame(ID,FTP.C.1,'Cluster'=FTP.kmeans$cluster)
> ClusterResults <-data.frame("ID"=ID, FTP.kmeans.cluster)
> write.csv(ClusterResults, file= "ClustersALL1.csv")
>
> #measure of the total variance in the DATASET explained by the clustering
> FTP.kmeans$tot.withinss/FTP.kmeans$betweenss #prints between_SS/total_SS
[1] 0.6207187
> #RESULT: 62.1% of the total variance in the data set is explained by clustering.
>
> #####################WARDS###################################
>
> #runs wards test for DATASET
> diss<-dist(DATASET, method="euclidean")
```

```
Warning message:
In dist(DATASET, method = "euclidean") : NAs introduced by coercion
> FTP.ward<-hclust(diss,method = "ward.D2")
> windows()
> plot(FTP.ward,main="WARDS Dendrogram") #creates a dendrogram
```

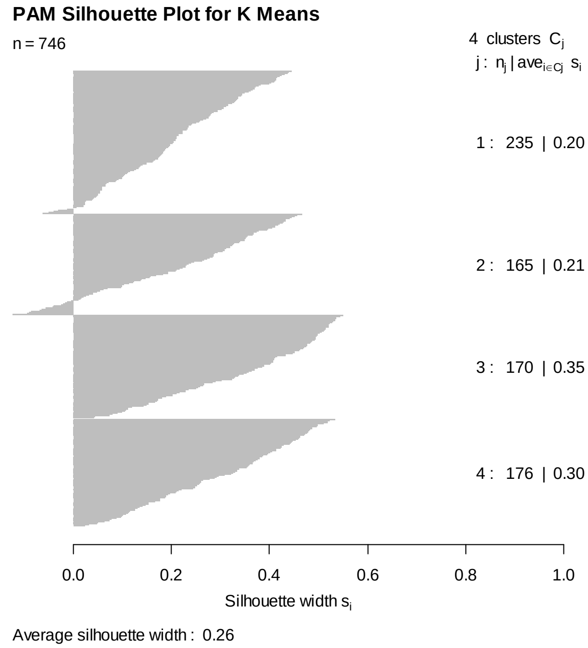



```
>
> #evaluate Ward and cluster into K clusters
> wardK<-cutree(FTP.ward,K) #choose K clusters
> wardK<-as.factor(wardK)
> FTP.W<-data.frame(DATASET,WClusterK=wardK) #creates dataframe with composite variables and clus
ter
>
> #create cluster plot
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.W$WClusterK,main="WARDS Cluster Pl
ot")
```

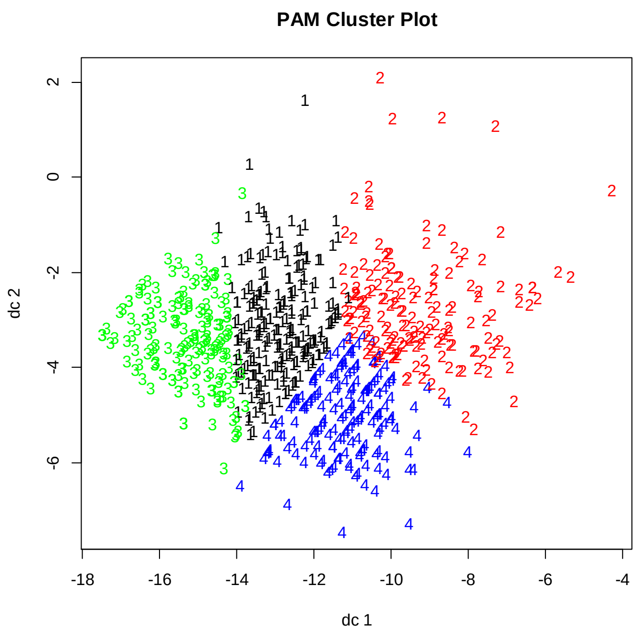



```
>
> #Calculating the number in each group
> N<-aggregate(FTP.W$kPF~WClusterK,data=FTP.W,FUN=length)
>
> #Calculate group means for each factor
> kPF.W<-aggregate(FTP.W$kPF~WClusterK,data=FTP.W, FUN=mean)#group means for Perceptions of the F
uture
> kPF.W<-as.data.frame(kPF.W$`FTP.W$kPF`)#create column with just the averages
> N<-as.data.frame(cbind(N,kPF.W))#adjoin to table
>
> kCL.W<-aggregate(FTP.W$kCL~WClusterK,data=FTP.W, FUN=mean)#group means for Perceived instrument
ality
> kCL.W<-as.data.frame(kCL.W$`FTP.W$kCL`)
> N<-as.data.frame(cbind(N,kCL.W))
>
> kAL.W<-aggregate(FTP.W$kAL~WClusterK,data=FTP.W, FUN=mean)
> kAL.W<-as.data.frame(kAL.W$`FTP.W$kAL`)
> N<-as.data.frame(cbind(N,kAL.W))
>
> #rename rows
> rename(N,c("WClusterK"="Cluster","FTP.W$kPF"="N",
+            "kPF.W$`FTP.W$kPF`"="kPF",
+            "kCL.W$`FTP.W$kCL`"="kCL",
+            "kAL.W$`FTP.W$kAL`"="kAL"))
  Cluster   N      kPF      kCL      kAL
1       1 344 5.492006 4.553488 5.334787
2       2 135 4.429630 2.903704 3.769136
3       3 125 5.886000 2.894400 5.070667
4       4 142 6.373239 6.074648 6.110329
> #Shows clusters, N, and averages
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #spits out a table with pvalue for each pair of clusters
> pairwise.t.test(FTP.W$kPF,FTP.W$WClusterK,p.adj="none")
```

```
         Pairwise comparisons using t tests with pooled SD

data:  FTP.W$kPF and FTP.W$WClusterK

  1       2       3
2 < 2e-16 -       -
3 3.6e-05 < 2e-16 -
4 < 2e-16 < 2e-16 1.4e-05

P value adjustment method: none
> pairwise.t.test(FTP.W$kCL,FTP.W$WClusterK,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  FTP.W$kCL and FTP.W$WClusterK

  1      2      3
2 <2e-16 -      -
3 <2e-16 0.91   -
4 <2e-16 <2e-16 <2e-16

P value adjustment method: none
> pairwise.t.test(FTP.W$kAL,FTP.W$WClusterK,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  FTP.W$kAL and FTP.W$WClusterK

  1       2       3
2 < 2e-16 -       -
3 0.00038 < 2e-16 -
4 < 2e-16 < 2e-16 < 2e-16

P value adjustment method: none
> #RESULTS: not all significantly different
>
>
> ############################PAM#############################
> #Partitioning Around Medoids
> FTP.dist<-dist(DATASET) #create a distance matrix
> FTP.pam<-pam(FTP.dist,K)
>
> #Find the silhouette (indicates if good structure to the clusters and "belonging" of data to cl
usters they're in)
> #.71-1.0 is strong, .51-.7 reasonable, .26-.5 weak, <.25 no substantial structure
> #RESULTS: weak to no substantial structure
> windows()
> plot(FTP.pam, main="PAM Silhouette Plot for K Means")
```

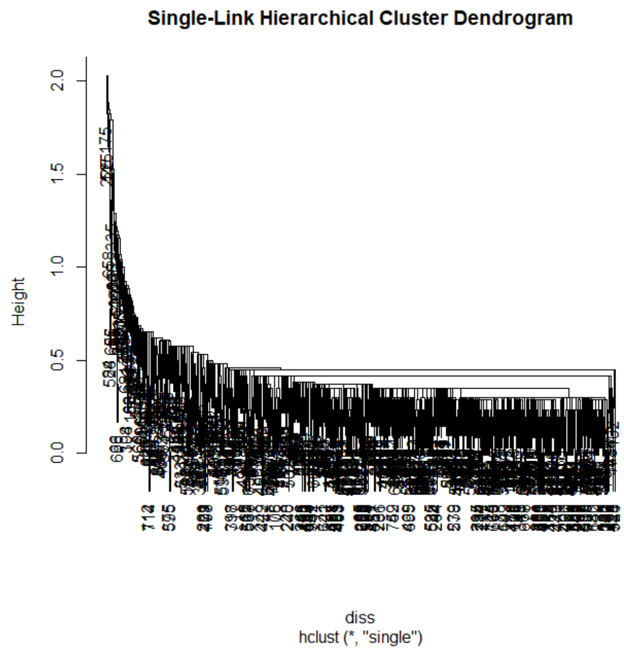



```
>
> #create cluster plot
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.pam$clustering,main="PAM Cluster P
lot")
```

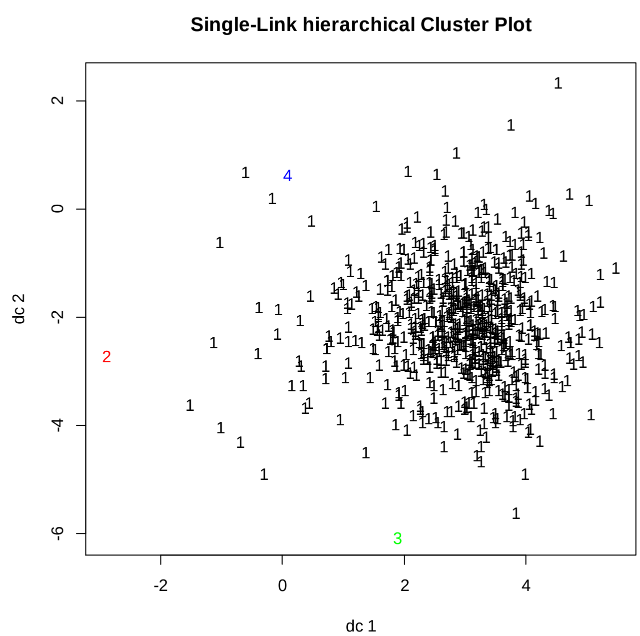



```
>
> aggregate (cbind('kCL'=DATASET$kCL, 'kAL'=DATASET$kAL, 'kPF'=DATASET$kPF),by=list(FTP.pam$clust
er),FUN=mean) #cluster means
  Group.1      kCL      kAL      kPF
1       1 4.811064 5.172340 5.603191
2       2 3.203636 3.981818 4.165152
3       3 5.834118 6.206863 6.408824
4       4 3.021591 5.214962 5.877841
```

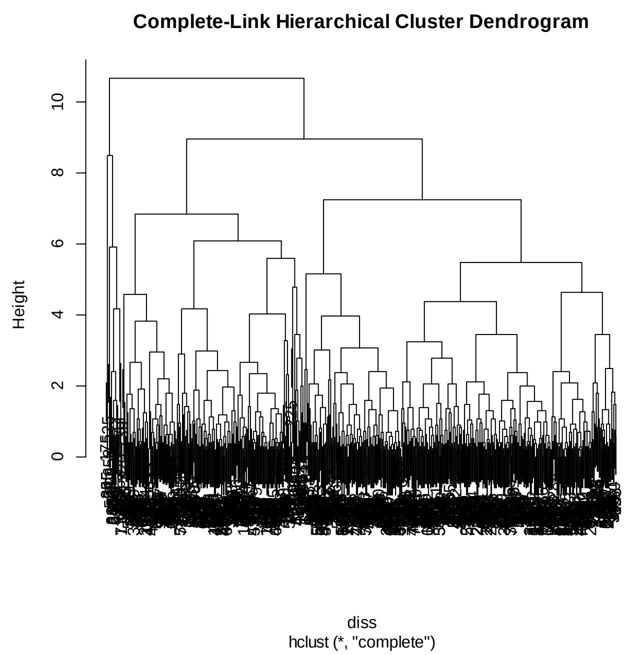
```
> aggregate (DATASET$ID,by=list(FTP.pam$cluster), FUN=length) #number of participants in each clu
ster
  Group.1   x
1       1 235
2       2 165
3       3 170
4       4 176
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #spits out a table with pvalue for each pair of clusters
> pairwise.t.test(DATASET$kPF,FTP.pam$clustering,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kPF and FTP.pam$clustering

  1       2       3
2 < 2e-16 -       -
3 < 2e-16 < 2e-16 -
4 0.00032 < 2e-16 1.6e-10

P value adjustment method: none
> pairwise.t.test(DATASET$kCL,FTP.pam$clustering,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kCL and FTP.pam$clustering

  1      2      3
2 <2e-16 -      -
3 <2e-16 <2e-16 -
4 <2e-16 0.019  <2e-16

P value adjustment method: none
> pairwise.t.test(DATASET$kAL,FTP.pam$clustering,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kAL and FTP.pam$clustering

  1      2      3
2 <2e-16 -      -
3 <2e-16 <2e-16 -
4 0.54   <2e-16 <2e-16

P value adjustment method: none
> #RESULTS: not all significantly different
>
> ################# DIVISIVE HIERARCHICAL ####################
> ## SINGLE LINK HIERARCHICAL
> diss<-dist(DATASET, method="euclidean")
> windows()
```



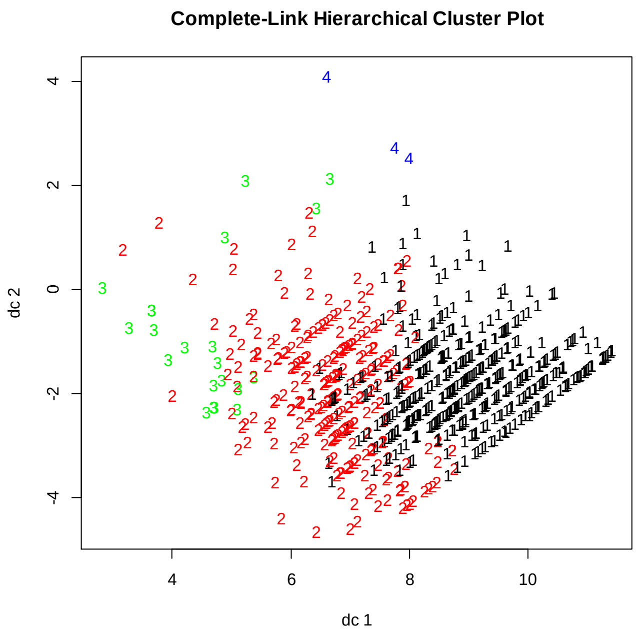

```
> FTP.sing<-hclust(diss,method = "single")
> plot(FTP.sing, main="Single-Link Hierarchical Cluster Dendrogram") #creates a dendrogram
> #RESULTS: Dendrogram looks bad, splits too early
>
> #evaluate Complete for K clusters
> compK <-cutree(FTP.sing,K)#choose K clusters
> compK<-as.factor(compK)
> FTP.SLH<-data.frame(DATASET,CCluster4=compK) #creates dataframe with composite variables and cl
uster
>
> #create cluster plot
> windows()
```



```
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.SLH$CCluster4,main="Single-Link hi
erarchical Cluster Plot")
> #RESULTS: poor solution reflected in the cluster plot
>
> #Clusters too small to run t-tests
>
>
> ## COMPLETE-LINK HIERARCHICAL
> diss<-dist(DATASET, method="euclidean")
Warning message:
In dist(DATASET, method = "euclidean") : NAs introduced by coercion
> FTP.comp<-hclust(diss,method = "complete")
> windows()
> plot(FTP.comp, main="Complete-Link Hierarchical Cluster Dendrogram") #creates a dendrogram
```

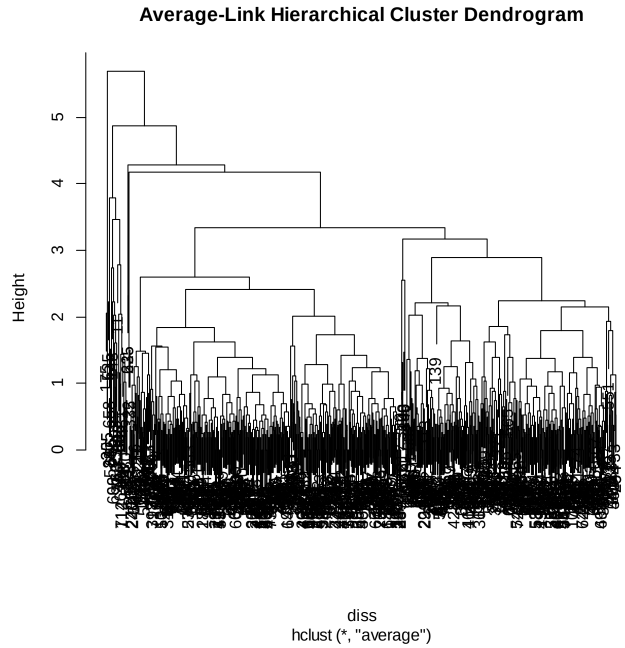



```
>
> #evaluate Complete for K clusters
> compK <-cutree(FTP.comp,K)#choose K clusters
> compK<-as.factor(compK)
> FTP.CLH<-data.frame(DATASET,CCluster4=compK) #creates dataframe with composite variables and cl
uster
>
> #create cluster plot
> windows()
```

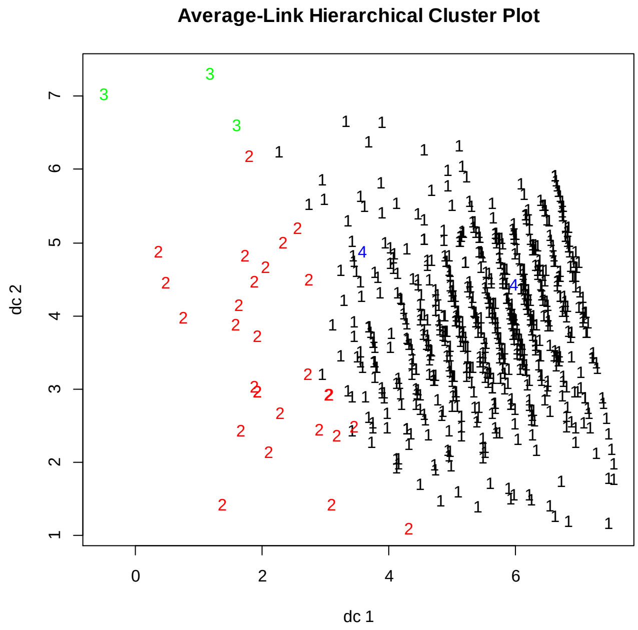



```
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.CLH$CCluster4,main="Complete-Link
Hierarchical Cluster Plot")
> #RESULTS: poor solution reflected in the cluster plot
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #spits out a table with pvalue for each pair of clusters
> pairwise.t.test(DATASET$kPF,FTP.CLH$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kPF and FTP.CLH$CCluster4

  1       2       3
2 < 2e-16 -       -
3 < 2e-16 < 2e-16 -
4 3.2e-15 7.2e-09 0.071

P value adjustment method: none
> pairwise.t.test(DATASET$kCL,FTP.CLH$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kCL and FTP.CLH$CCluster4

  1       2       3
2 < 2e-16 -       -
3 < 2e-16 0.00520 -
4 0.00058 1.7e-10 2.5e-12

P value adjustment method: none
> pairwise.t.test(DATASET$kAL,FTP.CLH$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kAL and FTP.CLH$CCluster4
```

```
  1        2        3
2 < 2e-16 -        -
3 < 2e-16 3.7e-15 -
4 0.08278 0.00087 1.7e-09

P value adjustment method: none
> #RESULTS: not all significantly different
>
> ## AVERAGE-LINK HIERARCHICAL
> diss<-dist(DATASET, method="euclidean")
Warning message:
In dist(DATASET, method = "euclidean") : NAs introduced by coercion
> FTP.avg<-hclust(diss,method = "average")
> windows()
> plot(FTP.avg, main="Average-Link Hierarchical Cluster Dendrogram")#creates a dendrogram
```

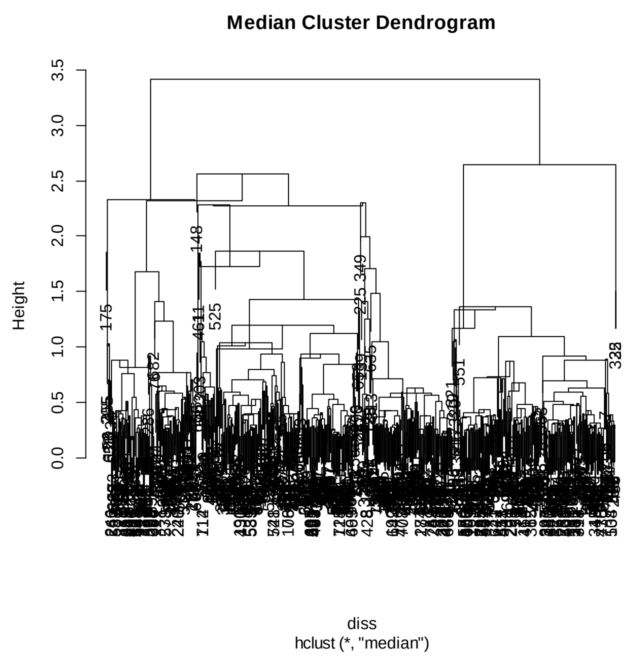



```
> #evaluate Complete for K clusters
> compK <-cutree(FTP.avg,K)#choose K clusters
> compK<-as.factor(compK)
> FTP.ALH<-data.frame(DATASET,CCluster4=compK) #creates dataframe with composite variables and cl
uster
>
> #create cluster plot
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.ALH$CCluster4,main="Average-Link H
ierarchical Cluster Plot")
```

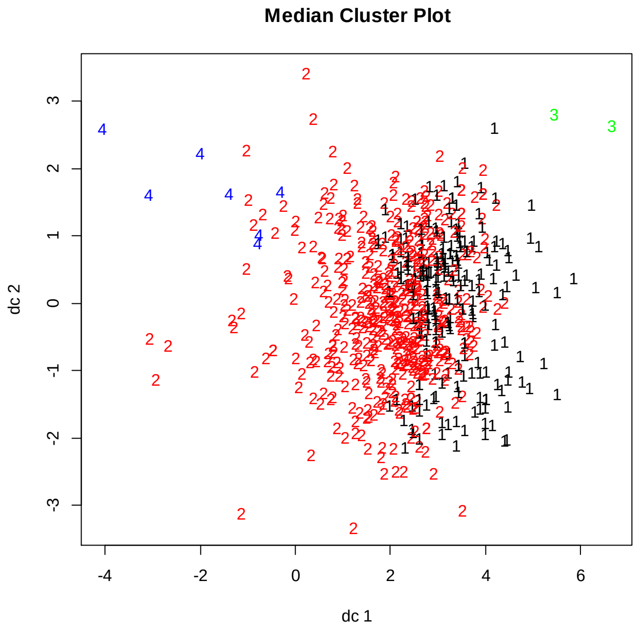



```
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #spits out a table with pvalue for each pair of clusters
> pairwise.t.test(DATASET$kPF,FTP.ALH$CCluster4,p.adj="none")

        Pairwise comparisons using t tests with pooled SD

data:  DATASET$kPF and FTP.ALH$CCluster4

  1       2       3
2 < 2e-16 -       -
3 1.2e-11 0.36261 -
4 0.29570 0.00025 0.00040

P value adjustment method: none
> pairwise.t.test(DATASET$kCL,FTP.ALH$CCluster4,p.adj="none")

        Pairwise comparisons using t tests with pooled SD

data:  DATASET$kCL and FTP.ALH$CCluster4

  1       2       3
2 1.6e-05 -       -
3 0.00051 3.1e-06 -
4 0.00488 0.11261 1.2e-05

P value adjustment method: none
> pairwise.t.test(DATASET$kAL,FTP.ALH$CCluster4,p.adj="none")

        Pairwise comparisons using t tests with pooled SD

data:  DATASET$kAL and FTP.ALH$CCluster4

  1       2       3
2 4.1e-12 -       -
```

```
3 0.036   2.5e-05 -
4 0.013   2.4e-05 0.556

P value adjustment method: none
> #RESULTS: not all significantly different
>
> ## MEDIAN
> diss<-dist(DATASET, method="euclidean")
> FTP.med<-hclust(diss,method = "median")
> windows()
> plot(FTP.med,main="Median Cluster Dendrogram") #creates a dendrogram
```

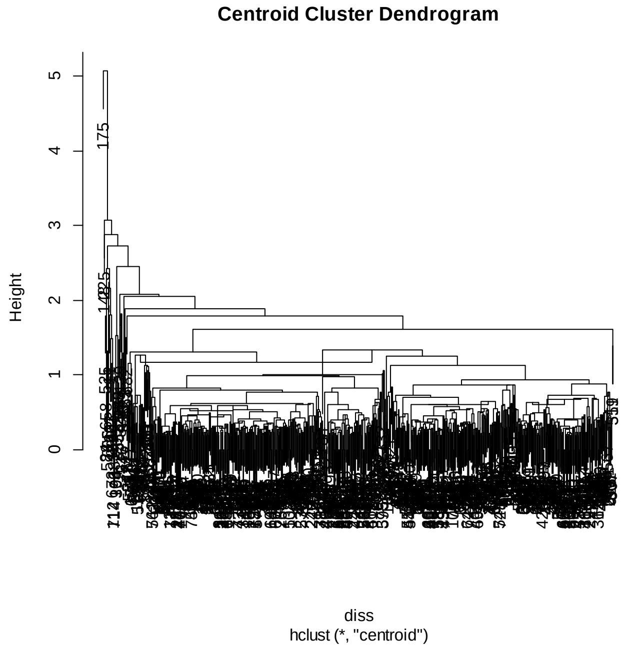



```
>
> #evaluate Complete for K clusters
> compK <-cutree(FTP.med,K)#choose K clusters
> compK<-as.factor(compK)
> FTP.MED<-data.frame(DATASET,CCluster4=compK) #creates dataframe with composite variables and cl
uster
>
> #create cluster plot
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.MED$CCluster4,main="Median Cluster
Plot")
```

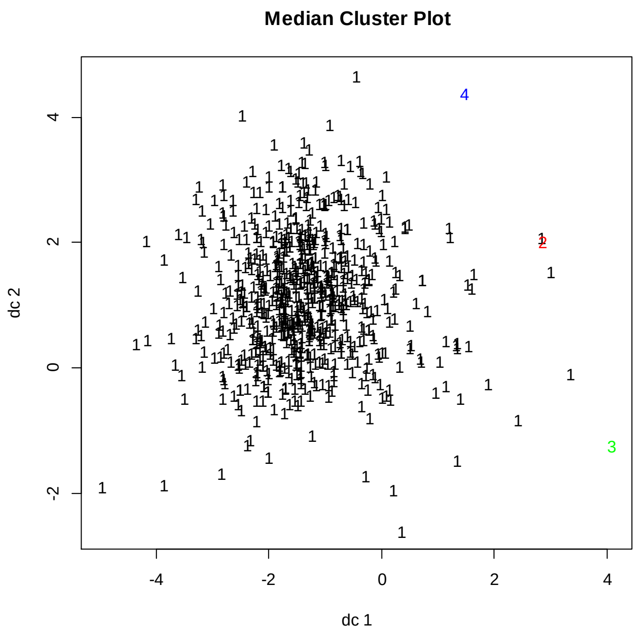



```
> #RESULTS: poor solution reflected in the cluster plot
>
> #Run t-tests to show that clusters are sig dif (if they even are) for each construct
> #spits out a table with pvalue for each pair of clusters
> pairwise.t.test(DATASET$kPF,FTP.MED$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kPF and FTP.MED$CCluster4

  1       2       3
2 < 2e-16 -       -
3 0.31    0.02    -
4 < 2e-16 5.7e-10 5.6e-07

P value adjustment method: none
> pairwise.t.test(DATASET$kCL,FTP.MED$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kCL and FTP.MED$CCluster4

  1       2       3
2 0.022   -       -
3 0.054   0.029   -
4 9.9e-05 1.1e-05 0.871

P value adjustment method: none
> pairwise.t.test(DATASET$kAL,FTP.MED$CCluster4,p.adj="none")

         Pairwise comparisons using t tests with pooled SD

data:  DATASET$kAL and FTP.MED$CCluster4

  1       2       3
```

```
2 0.12795 -       -
3 0.00396 0.00225 -
4 0.00564 0.01329 0.00011

P value adjustment method: none
> #RESULTS: not all significantly different
>
> ## CENTROID
> diss<-dist(DATASET, method="euclidean")
> FTP.centroid<-hclust(diss,method = "centroid")
> windows()
> plot(FTP.centroid, main="Centroid Cluster Dendrogram") #creates a dendrogram
```




```
>
> #evaluate Complete for K clusters
> compK <-cutree(FTP.centroid,K)#choose K clusters
> compK<-as.factor(compK)
> FTP.CENT<-data.frame(DATASET,CCluster4=compK) #creates dataframe with composite variables and c
luster
>
> #create cluster plot
> windows()
> plotcluster(cbind(DATASET$kCL, DATASET$kAL, DATASET$kPF),FTP.CENT$CCluster4,main="Median Cluste
r Plot")
```




```
> #RESULTS: poor solution reflected in the cluster plot
>
> #Clusters too small to run t-tests

> ########################  DEMOGRAPHICS ########################
>
> DemoData <-read.csv(file.choose()) #Choose "All Data Cleaned_listwise for demographics.csv"
> attach(DemoData)
The following objects are masked _by_ .GlobalEnv:

    Course, Duel, Emphasis, Fam_Eng, Fam_non, Fam_STEM, Gender, ID, Major, Me_US, Parent1_Ed, Par
ent1_US, Parent2_Ed, Parent2_US, Race, Univ,
    Year

The following objects are masked from myData:

    C_1, C_2, C_3, C_4, C_5, Can.use.1, Course, Date, Duel, Emphasis, F_1, F_2, F_3, F_4, Fam_Eng
, Fam_non, Fam_STEM, FoP_1, FoP_2, FoP_3,
    Gender, Gender_other, ID, Major, Me_US, Minor, Parent1_Ed, Parent1_US, Parent2_Ed, Parent2_US
, PIEN_1, PIEN_2, PIEN_3, PIEN_4, PIEN_5,
    PIEX_1, PIEX_2, PIEX_3, PIEX_4, Race, Race_other, Sex_Id, Sex_Id_other, TA_1, TA_2, TA_3, TA_
4, TA_5, TA_6, Univ, V_1, V_2, V_3, V_4,
    X18.years.old..1, Year


>
> ClusterData<-merge(FTP2,DemoData, by="ID") #Creates Data frame with all data and cluster assign
ments
>
> WaffleData <-subset(ClusterData,Cluster.x==1) #Creates a Dataset with only participants in Waff
le
> nrow(WaffleData) #Should be number of participants in Waffle
[1] 176
> #CHECK: n=176
>
> SugarData <-subset(ClusterData,Cluster.x==2) #Creates a Dataset with only participants in Sugar
```

```
> nrow(SugarData) #Should be number of participants in Sugar
[1] 210
> #CHECK: n=210
>
> NewData <-subset(ClusterData,Cluster.x==3) #Creates a Dataset with only participants in New
> nrow(NewData) #Should be number of participants in Cake
[1] 141
> #CHECK: n=141
>
> CakeData <-subset(ClusterData,Cluster.x==4) #Creates a Dataset with only participants in Cake
> nrow(CakeData) #Should be number of participants in Cake
[1] 219
> #CHECK: n=219
>
> #UNIVERSITY
>
> #All
> describe(DemoData$Univ)
DemoData$Univ
       n  missing distinct
     746        0        5

Value          A     B     C     D     F
Frequency     14    55   292   274   111
Proportion 0.019 0.074 0.391 0.367 0.149
> #RESULTS: Univ A (n=14)   Univ B (n=55)   Univ C (n=292)   Univ D (n=274)    Univ F (n=111)
> #RESULTS: 1.9%            7.4%            39.1%            36.7%             14.9%
>
>
>
> #Waffle
> describe(WaffleData$Univ)
WaffleData$Univ
       n  missing distinct
     176        0        5

Value          A     B     C     D     F
Frequency      7     9    63    78    19
Proportion 0.040 0.051 0.358 0.443 0.108
> #RESULTS: Univ A (n=7)    Univ B (n=9)    Univ C (n=63)    Univ D (n=78)     Univ F (n=19)
> #RESULTS: 4.0%            5.1%            35.8%            44.3%             10.8%
> #Sugar
> describe(SugarData$Univ)
SugarData$Univ
       n  missing distinct
     210        0        5

Value          A     B     C     D     F
Frequency      1    11    78    83    37
Proportion 0.005 0.052 0.371 0.395 0.176
> #RESULTS: Univ A (n=1)    Univ B (n=11)   Univ C (n=78)    Univ D (n=83)     Univ F (n=37)
> #RESULTS: 0.5%            5.2%            37.1%            39.5%             17.6%
> #New
> describe(NewData$Univ)
NewData$Univ
       n  missing distinct
     141        0        5
```

```
Value          A     B     C     D     F
Frequency      4    10    63    46    18
Proportion 0.028 0.071 0.447 0.326 0.128
> #RESULTS: Univ A (n=4)    Univ B (n=10)   Univ C (n=63)    Univ D (n=46)     Univ F (n=18)
> #RESULTS: 2.8%            7.1%            44.7%            32.6%             12.8%
> #Cake
> describe(CakeData$Univ)
CakeData$Univ
       n  missing distinct
     219        0        5

Value          A     B     C     D     F
Frequency      2    25    88    67    37
Proportion 0.009 0.114 0.402 0.306 0.169
> #RESULTS: Univ A (n=2)    Univ B (n=25)   Univ C (n=88)    Univ D (n=67)     Univ F (n=37)
> #RESULTS: 0.9%            11.4%           40.2%            30.6%             16.9%
> #University C
> UnivC<-subset(ClusterData, Univ=='C')
> describe(UnivC$Cluster.x)
UnivC$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     292        0        4    0.933    2.603    1.263

Value          1     2     3     4
Frequency     63    78    63    88
Proportion 0.216 0.267 0.216 0.301
> #RESULT: Waffle(n=63)   Sugar(n=78)    New(n=63)    Cake(n=88)
> #RESULT: 21.6%          26.7%          21.6%        30.1%
> #University D
> UnivD<-subset(ClusterData, Univ=='D')
> describe(UnivD$Cluster.x)
UnivD$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     274        0        4     0.93    2.372    1.266

Value          1     2     3     4
Frequency     78    83    46    67
Proportion 0.285 0.303 0.168 0.245
> #RESULT: Waffle(n=78)   Sugar(n=83)    New(n=46)    Cake(n=67)
> #RESULT: 28.5%          30.3%          16.8%        24.5%
> ##YEAR IN SCHOOL
> #1=First Year, 2=Sophomore, 3=Junior, 4=Senior
>
> #All
> describe(DemoData$Year)
DemoData$Year
       n  missing distinct     Info     Mean      Gmd
     736       10        4     0.87    2.042   0.8697

Value          1     2     3     4
Frequency    198   341   165    32
Proportion 0.269 0.463 0.224 0.043
> #RESULTS: First-Year     Sophomore        Junior          Senior
> #RESULTS: (n=198) 26.9%  (n=341) 46.3%    (n=165) 22.4%    (n=32) 4.3%
> #RESULTS: Mid-year (n=518; 70.4%)
>
```

```
> #Waffle
> describe(WaffleData$Year)
WaffleData$Year
       n  missing distinct     Info     Mean      Gmd
     174        2        4    0.897    2.034   0.9989

Value          1     2     3     4
Frequency     57    68    35    14
Proportion 0.328 0.391 0.201 0.080
> #RESULTS: First-Year(n=57)      Sophomore(n=68)       Junior(n=35)         Senior(n=14)
> #RESULTS: 32.8%                 39.1%                 20.1%                8.0%
> #Sugar
> describe(SugarData$Year)
SugarData$Year
       n  missing distinct     Info     Mean      Gmd
     207        3        4    0.872    2.019   0.8401

Value          1     2     3     4
Frequency     57    93    53     4
Proportion 0.275 0.449 0.256 0.019
> #RESULTS: First-Year(n=57)      Sophomore(n=93)       Junior(n=53)         Senior(n=4)
> #RESULTS: 27.5%                 44.9%                 25.6%                1.9%
> #New
> describe(NewData$Year)
NewData$Year
       n  missing distinct     Info     Mean      Gmd
     140        1        4    0.863    2.114   0.9013

Value          1     2     3     4
Frequency     33    68    29    10
Proportion 0.236 0.486 0.207 0.071
> #RESULTS: First-Year(n=33)      Sophomore(n=68)       Junior(n=29)         Senior(n=10)
> #RESULTS: 23.6%                 48.6%                 20.7%                7.1%
> #Cake
> describe(CakeData$Year)
CakeData$Year
       n  missing distinct     Info     Mean      Gmd
     215        4        4    0.834    2.023   0.7687

Value          1     2     3     4
Frequency     51   112    48     4
Proportion 0.237 0.521 0.223 0.019
> #RESULTS: First-Year(n=51)      Sophomore(n=112)       Junior(n=48)         Senior(n=4)
> #RESULTS: 23.7%                 52.1%                  22.3%                1.9%
> #First-Year
> Freshmen<-subset(ClusterData, Year==1)
> describe(Freshmen$Cluster.x)
Freshmen$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     198        0        4    0.931    2.394    1.287

Value          1     2     3     4
Frequency     57    57    33    51
Proportion 0.288 0.288 0.167 0.258
> #RESULT: Waffle(n=57)    Sugar(n=57)    New(n=33)    Cake(n=51)
> #RESULT: 28.8%           28.8%           16.7%        25.8%
> #Sophomore
```

```
> Sophomore<-subset(ClusterData, Year==2)
> describe(Sophomore$Cluster.x)
Sophomore$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     341        0        4    0.928    2.657    1.263

Value          1     2     3     4
Frequency     68    93    68   112
Proportion 0.199 0.273 0.199 0.328
> #RESULT: Waffle(n=68)   Sugar(n=93)    New(n=68)    Cake(n=112)
> #RESULT: 19.9%          27.3%          19.9%        32.8%
> #Junior
> Junior<-subset(ClusterData, Year==3)
> describe(Junior$Cluster.x)
Junior$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     165        0        4    0.927    2.545    1.252

Value          1     2     3     4
Frequency     35    53    29    48
Proportion 0.212 0.321 0.176 0.291
> #RESULT: Waffle(n=35)   Sugar(n=53)    New(n=29)    Cake(n=48)
> #RESULT: 21.2%          32.1%          17.6%        29.1%
> #Seniors
> #Describes the distribution of clusters within seniors
> Seniors<-subset(ClusterData, Year==4)
> describe(Seniors$Cluster.x)
Seniors$Cluster.x
       n  missing distinct     Info     Mean      Gmd
      32        0        4    0.883    2.125    1.242

Value          1     2     3     4
Frequency     14     4    10     4
Proportion 0.438 0.125 0.312 0.125
> #RESULT: Waffle(n=14)   Sugar(n=4)    New(n=10)    Cake(n=4)
> #RESULT: 43.8%          12.5%         31.2%        12.5%
> #Mid-Year
> MidYear<-subset(ClusterData, Year==2|Year==3)
> describe(MidYear$Cluster.x)
MidYear$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     506        0        4    0.929    2.621    1.259

Value          1     2     3     4
Frequency    103   146    97   160
Proportion 0.204 0.289 0.192 0.316
> #RESULT: Waffle(n=103)   Sugar(n=146)    New(n=97)    Cake(n=160)
> #RESULT: 20.4%           28.9%           19.2%        31.6%
>
>
> ## MAJOR
> #0=Non-Engineering, 1=Other Engineering, 2=Civil Engineering (CE), 3=Electrical Engineering (EE
and ECE), 4=Mechanical Engineering (ME)
>
> #All
> describe(DemoData$Engineering)
DemoData$Engineering
```

```
       n  missing distinct     Info     Mean      Gmd 
     746        0        5    0.907    2.295    1.424 

Value          0     1     2     3     4
Frequency     14   299    94   131   208
Proportion 0.019 0.401 0.126 0.176 0.279
> #RESULTS: Non-Engr (n=14)  Other Engineering (n=299)   CE (n=94)   EE (n=131)   ME (n=208)
> #RESULTS: 1.9%             40.1%                       12.6%       17.6%        27.9%
> 
> #Waffle
> describe(WaffleData$Engineering)
WaffleData$Engineering 
       n  missing distinct     Info     Mean      Gmd 
     176        0        5    0.899    2.131    1.437 

Value          0     1     2     3     4
Frequency      7    75    28    20    46
Proportion 0.040 0.426 0.159 0.114 0.261
> #RESULTS: Non-Engr (n=7)  Other Engineering (n=75)   CE (n=28)   EE (n=20)   ME (n=46)
> #RESULTS: 0.4%            42.6%                      15.9%       11.4%       26.1%
> #Sugar
> describe(SugarData$Engineering)
SugarData$Engineering 
       n  missing distinct     Info     Mean      Gmd 
     210        0        5    0.892    2.176    1.374 

Value          0     1     2     3     4
Frequency      3    93    27    38    49
Proportion 0.014 0.443 0.129 0.181 0.233
> #RESULTS: Non-Engr (n=3)  Other Engineering (n=93)   CE (n=27)   EE (n=38)   ME (n=49)
> #RESULTS: 1.4%            44.3%                      12.9%       18.1%       23.3%
> #New
> describe(NewData$Engineering)
NewData$Engineering 
       n  missing distinct     Info     Mean      Gmd 
     141        0        5    0.909    2.447    1.452 

Value          0     1     2     3     4
Frequency      2    51    17    24    47
Proportion 0.014 0.362 0.121 0.170 0.333
> #RESULTS: Non-Engr (n=2)  Other Engineering (n=51)   CE (n=17)   EE (n=24)   ME (n=47)
> #RESULTS: 1.4%            36.2%                      12.1%       17.0%       33.3%
> #Cake
> describe(CakeData$Engineering)
CakeData$Engineering 
       n  missing distinct     Info     Mean      Gmd 
     219        0        5    0.912    2.443    1.413 

Value          0     1     2     3     4
Frequency      2    80    22    49    66
Proportion 0.009 0.365 0.100 0.224 0.301
> #RESULTS: Non-Engr (n=2)  Other Engineering (n=80)   CE (n=17)   EE (n=24)   ME (n=47)
> #RESULTS: 0.9%            36.5%                      10.0%       22.4%       30.1%
> #Civil Engineering
> CE<-subset(ClusterData,Engineering==2)
> describe(CE$Cluster.x)
CE$Cluster.x 
```

```
       n  missing distinct     Info     Mean      Gmd
      94        0        4    0.931    2.351    1.276

Value          1     2     3     4
Frequency     28    27    17    22
Proportion 0.298 0.287 0.181 0.234
> #RESULT: Waffle(n=28)   Sugar(n=27)    New(n=17)    Cake(n=22)
> #RESULT: 29.8%          28.7%          18.1%        23.4%
> #Electical Engineering
> EE<-subset(ClusterData,Engineering==3)
> describe(EE$Cluster.x)
EE$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     131        0        4    0.914    2.779     1.23

Value          1     2     3     4
Frequency     20    38    24    49
Proportion 0.153 0.290 0.183 0.374
> #RESULT: Waffle(n=20)   Sugar(n=38)    New(n=24)    Cake(n=49)
> #RESULT: 15.3%          29.0%          18.3%        37.4%
> #Mechanical Engineering
> ME<-subset(ClusterData,Engineering==4)
> describe(ME$Cluster.x)
ME$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     208        0        4    0.933    2.639     1.28

Value          1     2     3     4
Frequency     46    49    47    66
Proportion 0.221 0.236 0.226 0.317
> #RESULT: Waffle(n=46)   Sugar(n=49)    New(n=47)    Cake(n=66)
> #RESULT: 22.1%          23.6%          22.6%        31.7%
> #Other Engineering
> Engr<-subset(ClusterData,Engineering==1)
> describe(Engr$Cluster.x)
Engr$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     299        0        4     0.93    2.455    1.264

Value          1     2     3     4
Frequency     75    93    51    80
Proportion 0.251 0.311 0.171 0.268
> #RESULT: Waffle(n=75)   Sugar(n=93)    New(n=51)    Cake(n=80)
> #RESULT: 25.1%          31.1%          17.1%        26.8%
> #Non-Engineering
> NonEngr<-subset(ClusterData,Engineering==0)
> describe(NonEngr$Cluster.x)
NonEngr$Cluster.x
       n  missing distinct     Info     Mean      Gmd
      14        0        4    0.864    1.929    1.242

Value          1     2     3     4
Frequency      7     3     2     2
Proportion 0.500 0.214 0.143 0.143
> #RESULT: Waffle(n=7)   Sugar(n=3)    New(n=2)    Cake(n=2)
> #RESULT: 50.0%         21.4%         14.3%       14.3%
> #RACE
```

```
> #1=American Indian, 2=Asian, 3=Black, 4=Hispanic, 5=Middle Eastern, 6=Pacific Islander, 7=White
, 8=Other
>
> #All
> describe(DemoData$Race)
DemoData$Race
       n  missing distinct
     746        0       28

lowest :         1       1,3,4,5 1,3,4,7 1,3,7   , highest: 5,7     6,7     7       7,8     8
> Race <- as.data.frame(table(DemoData$Race))
> print(Race)
      Var1 Freq
1             1
2        1    5
3  1,3,4,5    1
4  1,3,4,7    2
5    1,3,7    1
6    1,4,7    2
7      1,7   23
8        2   56
9      2,3    1
10 2,3,4,5    1
11   2,3,7    1
12   2,4,7    1
13     2,5    1
14     2,7   17
15     2,8    1
16       3   24
17   3,4,7    1
18     3,7    2
19   3,7,8    1
20       4   27
21     4,6    1
22     4,7   15
23       5    9
24     5,7    5
25     6,7    2
26       7  535
27     7,8    1
28       8    9
> #RESULTS: White (n=535)   Asian (n=56)    Hispanic(n=27)    Black (n=24)
> #RESULTS: 71.7%           7.5%            3.6%              3.2%
>
> #Waffle
> describe(WaffleData$Race)
WaffleData$Race
       n  missing distinct
     176        0       15

Value            1 1,3,4,7   1,3,7     1,7       2 2,3,4,5   2,3,7     2,7       3       4     4,
7     5     6,7       7       8
Frequency        1       1       1       6      15       1       1       3       5       7
3     4       1     125       2
Proportion   0.006   0.006   0.006   0.034   0.085   0.006   0.006   0.017   0.028   0.040   0.01
7   0.023   0.006   0.710   0.011
> #RESULTS: White (n=125)   Asian (n=15)    Hispanic(n=5)    Black (n=5)
```

```
> #RESULTS: 71.0%           8.5%            2.3%             1.7%
>
> #Sugar
> describe(SugarData$Race)
SugarData$Race
       n  missing distinct
     210        0       15

Value          1 1,4,7   1,7     2 2,4,7   2,7   2,8     3     4   4,7     5   5,7   6,7     7
8
Frequency      1     1     8     7     1     4     1     7    11     6     1     2     1   157
2
Proportion 0.005 0.005 0.038 0.033 0.005 0.019 0.005 0.033 0.052 0.029 0.005 0.010 0.005 0.748 0.
010
> #RESULTS: White (n=157)   Asian (n=7)    Hispanic(n=11)    Black (n=7)
> #RESULTS: 74.8%           3.3%           5.2%              3.3%
> #New
> describe(NewData$Race)
NewData$Race
       n  missing distinct
     141        0       16

Value            1 1,3,4,5   1,4,7     1,7       2     2,3     2,5     2,7       3     3,7
4     4,7       5     5,7       7       8
Frequency        1       1       1       3      19       1       1       6       4       1
3       4       2       1      92       1
Proportion   0.007   0.007   0.007   0.021   0.135   0.007   0.007   0.043   0.028   0.007   0.02
1   0.028   0.014   0.007   0.652   0.007
> #RESULTS: White (n=92)   Asian (n=19)    Hispanic(n=3)     Black (n=4)
> #RESULTS: 65.2%          13.5%           2.1%              2.8%
> #Cake
> describe(CakeData$Race)
CakeData$Race
       n  missing distinct
     219        0       18

Value                    1 1,3,4,7     1,7       2     2,7       3   3,4,7     3,7   3,7,8
4     4,6     4,7       5     5,7       7     7,8       8
Frequency        1       2       1       6      15       4       8       1       1       1
6       1       2       2       2     161       1       4
Proportion   0.005   0.009   0.005   0.027   0.068   0.018   0.037   0.005   0.005   0.005   0.02
7   0.005   0.009   0.009   0.009   0.735   0.005   0.018
> #RESULTS: White (n=161)   Asian (n=15)    Hispanic(n=6)     Black (n=8)
> #RESULTS: 73.5%           6.8%            2.7%              3.7%
>
> #Black/African American
> Black<-subset(ClusterData,Race==3)
> describe(Black$Cluster.x)
Black$Cluster.x
       n  missing distinct     Info     Mean      Gmd
      24        0        4    0.926    2.625     1.33

Value          1     2     3     4
Frequency      5     7     4     8
Proportion 0.208 0.292 0.167 0.333
> #RESULT: Waffle(n=5)    Sugar(n=7)    New(n=4)    Cake(n=8)
> #RESULT: 20.8%          29.2%         16.7%       33.3%
```

```
> #White
> White<-subset(ClusterData,Race==7)
> describe(White$Cluster.x)
White$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     535        0        4     0.93     2.54     1.28

Value          1     2     3     4
Frequency    125   157    92   161
Proportion 0.234 0.293 0.172 0.301
> #RESULT: Waffle(n=125)    Sugar(n=157)    New(n=92)    Cake(n=161)
> #RESULT: 23.4%            29.3%           17.2%        30.1%
> #Asian
> Asian<-subset(ClusterData,Race==2)
> describe(Asian$Cluster.x)
Asian$Cluster.x
       n  missing distinct     Info     Mean      Gmd
      56        0        4    0.921    2.607    1.284

Value          1     2     3     4
Frequency     15     7    19    15
Proportion 0.268 0.125 0.339 0.268
> #RESULT: Waffle(n=15)    Sugar(n=7)    New(n=19)    Cake(n=15)
> #RESULT: 26.8%           12.5%         33.9%        26.8%
> #GENDER
> #1=Male, 2=Female, 3=Agender, 4=Genderqueer, 5=Cisgender, 6=Transgender, 7=Other
>
> #All
> describe(DemoData$Gender)
DemoData$Gender
       n  missing distinct
     746        0        9

Value                1   1,5   1,7     2   2,5   3,4     4     7
Frequency      1   539    23     1   171     8     1     1     1
Proportion 0.001 0.723 0.031 0.001 0.229 0.011 0.001 0.001 0.001
> #RESULTS: Total= 745
> #RESULTS: Male or Cis-Male     (n=539+23= 562; 75.4%)
> #RESULTS: Female or Cis-Female (n=171+8= 179;  24.0%)
> #RESULTS: Non-Binary           (n=4 <1%)
>
> #Waffle
> describe(WaffleData$Gender)
WaffleData$Gender
       n  missing distinct
     176        0        5

Value          1   1,5     2   2,5     4
Frequency    121     9    43     2     1
Proportion 0.688 0.051 0.244 0.011 0.006
> #RESULTS: Male or Cis-Male(n=130)     Female or Cis-Female (n=45)   Non-Binary(n=1)
> #RESULTS: 73.9%                       25.6%
>
> #Sugar
> describe(SugarData$Gender)
SugarData$Gender
       n  missing distinct
```

```
     210        0        5

Value          1   1,5   1,7     2   2,5
Frequency    155     4     1    49     1
Proportion 0.738 0.019 0.005 0.233 0.005
> #RESULTS: Male or Cis-Male(n=159)     Female or Cis-Female (n=50)   Non-Binary(n=1)
> #RESULTS: 73.9%                       12.2%
> #New
> describe(NewData$Gender)
NewData$Gender
       n  missing distinct
     141        0        4

Value          1   1,5     2   2,5
Frequency    100     2    37     2
Proportion 0.709 0.014 0.262 0.014
> #RESULTS: Male or Cis-Male(n=102)     Female or Cis-Female (n=39)   Non-Binary(n=0)
> #RESULTS: 72.3%                       27.7%
> #Cake
> describe(CakeData$Gender)
CakeData$Gender
       n  missing distinct
     219        0        7

Value                1   1,5     2   2,5   3,4     7
Frequency      1   163     8    42     3     1     1
Proportion 0.005 0.744 0.037 0.192 0.014 0.005 0.005
> #RESULTS: Male or Cis-Male(n=171)     Female or Cis-Female (n=45)   Non-Binary(n=2)
> #RESULTS: 73.9%                       20.5%
>
> #Female
> Female<-subset(ClusterData,Gender==2|Gender==2,5)
> describe(Female$Cluster.x)
Female$Cluster.x
       n  missing distinct     Info     Mean      Gmd
     171        0        4    0.936    2.456    1.251

Value          1     2     3     4
Frequency     43    49    37    42
Proportion 0.251 0.287 0.216 0.246
> #RESULT: Waffle(n=43)    Sugar(n=49)    New(n=37)    Cake(n=42)
> #RESULT: 25.1%           28.7%          21.6%        24.6%
> #Non-Binary Gender
> #NonBinary<-subset(ClusterData,Gender!=2 | Gender!=2,5 | Gender!=1 | Gender!=1,5)
> #describe(NonBinary$Cluster.x)
>
>
> #SEXUAL IDENTITY
> #1=Heterosexual, 2=Homosexual, 3=Bisexual, 4=Asexual, 5=Other
>
> #All
> describe(myData$Sex_Id)
myData$Sex_Id
       n  missing distinct
     767        0        8

Value                1   1,3     2     3   3,4     4     5
```

```
Frequency      4   732     1     7    17     1     2     3
Proportion 0.005 0.954 0.001 0.009 0.022 0.001 0.003 0.004
> #RESULTS: Heterosexual(n=712)  Homosexual(n=7)   Bisexual (n=17)     Asexual (n=1)
> #RESULTS: 95.4%                9%                2.3%                1%
> #Sugar
> describe(SugarData$Sex_Id)
SugarData$Sex_Id
       n  missing distinct
     210        0        5

Value                1   1,3     2     3
Frequency      1   204     1     1     3
Proportion 0.005 0.971 0.005 0.005 0.014
> #RESULTS: Heterosexual(n=204)  Homosexual(n=1)   Bisexual (n=3)     Hetero- and Bi-sexual (n=1)
> #RESULTS: 97.1%                0.5%              1.4%               0.5%
>
> #New
> describe(NewData$Sex_Id)
NewData$Sex_Id
       n  missing distinct
     141        0        4

Value          1     2     3     4
Frequency    134     1     4     2
Proportion 0.950 0.007 0.028 0.014
> #RESULTS: Heterosexual(n=134)  Homosexual(n=1)   Bisexual (n=4)     Asexual (n=2)
> #RESULTS: 95.0%                0.7%              2.4%               1.4%
>
> #Cake
> describe(CakeData$Sex_Id)
CakeData$Sex_Id
       n  missing distinct
     219        0        6

Value                1     2     3   3,4     5
Frequency      1   205     3     7     1     2
Proportion 0.005 0.936 0.014 0.032 0.005 0.009
> #RESULTS: Heterosexual(n=205)  Homosexual(n=3)   Bisexual (n=7)     Bi- and A- sexual (n=1)
> #RESULTS: 93.6%                1.4%              3.2%               0.05%
> describe(DemoData$Me_US)
DemoData$Me_US
       n  missing distinct     Info     Mean      Gmd
     745        1        2    0.242    1.089   0.1617

Value          1     2
Frequency    679    66
Proportion 0.911 0.089
> #RESULTS: Born in the US (n=679; 91.1%) Not born in the US (n=66; 8.9%)

> ######## MANOVA FOR YEAR ##################
> manova1<-manova(cbind(kPF,kCL,kAL)~as.factor(Year),data=ClusterData)
> summary(manova1)
                 Df   Pillai approx F num Df den Df  Pr(>F)
as.factor(Year)   3 0.028412   2.3329      9   2196 0.01297 *
Residuals       732
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

```
>
> #Can specify which test
> summary(manova1, test='Hotelling-Lawley')
                 Df Hotelling-Lawley approx F num Df den Df  Pr(>F)
as.factor(Year)   3         0.028784   2.3304      9   2186 0.01307 *
Residuals       732
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(manova1, test='Roy') #Rencher recommends not using Roy's test in any situation unless t
here is collinearity amongst the dependent variables (Rencher, n.d., pp. 177-177).
                 Df      Roy approx F num Df den Df  Pr(>F)
as.factor(Year)   3 0.017729   4.3259      3    732 0.00492 **
Residuals       732
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(manova1, test='Pillai')
                 Df   Pillai approx F num Df den Df  Pr(>F)
as.factor(Year)   3 0.028412   2.3329      9   2196 0.01297 *
Residuals       732
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> summary(manova1, test='Wilks')
                 Df   Wilks approx F num Df den Df  Pr(>F)
as.factor(Year)   3 0.97181   2.3334      9 1776.8 0.01302 *
Residuals       732
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
> #RESULTS: All tests are significant
>
> summary.aov(manova1) #Shows significants of individual factors
 Response kPF :
                 Df Sum Sq Mean Sq F value Pr(>F)
as.factor(Year)   3   5.79  1.9305  1.6103 0.1856
Residuals       732 877.55  1.1988

 Response kCL :
                 Df  Sum Sq Mean Sq F value Pr(>F)
as.factor(Year)   3    6.11  2.0382  1.1446 0.3302
Residuals       732 1303.41  1.7806

 Response kAL :
                 Df Sum Sq Mean Sq F value  Pr(>F)
as.factor(Year)   3   9.93  3.3096  3.2103 0.02255 *
Residuals       732 754.62  1.0309
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

10 observations deleted due to missingness
> #RESULTS: Alignment is significantly different p=0.02255
>
> t.test(subset(ClusterData, Year==1)$kAL, subset(ClusterData, Year==2)$kAL, p.adj="none")

         Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kAL and subset(ClusterData, Year == 2)$kAL
t = 0.42217, df = 427.03, p-value = 0.6731
alternative hypothesis: true difference in means is not equal to 0
```

```
95 percent confidence interval:
 -0.1369871  0.2119301
sample estimates:
mean of x mean of y 
 5.222222  5.184751 

> t.test(subset(ClusterData, Year==1)$kAL, subset(ClusterData, Year==3)$kAL, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kAL and subset(ClusterData, Year == 3)$kAL
t = 1.1928, df = 338.22, p-value = 0.2338
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.08325822  0.33982388
sample estimates:
mean of x mean of y 
 5.222222  5.093939 

> t.test(subset(ClusterData, Year==1)$kAL, subset(ClusterData, Year==4)$kAL, p.adj="none") #p=0.0
03584, AL is significantly lower for seniors than

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kAL and subset(ClusterData, Year == 4)$kAL
t = 3.0868, df = 41.805, p-value = 0.003584
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1977079 0.9446532
sample estimates:
mean of x mean of y 
 5.222222  4.651042 

> 
> t.test(subset(ClusterData, Year==2)$kAL, subset(ClusterData, Year==3)$kAL, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 2)$kAL and subset(ClusterData, Year == 3)$kAL
t = 0.91686, df = 315.23, p-value = 0.3599
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.1040642  0.2856868
sample estimates:
mean of x mean of y 
 5.184751  5.093939 

> t.test(subset(ClusterData, Year==2)$kAL, subset(ClusterData, Year==4)$kAL, p.adj="none") #p=0.0
0537, AL is significantly lower for seniors than sophomore

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 2)$kAL and subset(ClusterData, Year == 4)$kAL
t = 2.9613, df = 37.749, p-value = 0.005274
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.1687708 0.8986473
```

```
sample estimates:
mean of x mean of y
 5.184751  4.651042

>
> t.test(subset(ClusterData, Year==3)$kAL, subset(ClusterData, Year==4)$kAL, p.adj="none") #p=0.0
2428, AL is significantly lower for seniors than junior

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 3)$kAL and subset(ClusterData, Year == 4)$kAL
t = 2.3288, df = 46.392, p-value = 0.02428
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.06015893 0.82563652
sample estimates:
mean of x mean of y
 5.093939  4.651042

>
> t.test(subset(ClusterData, Year==1)$kPF, subset(ClusterData, Year==2)$kPF, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kPF and subset(ClusterData, Year == 2)$kPF
t = -0.87821, df = 386.59, p-value = 0.3804
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2809787  0.1074694
sample estimates:
mean of x mean of y
 5.469697  5.556452

> t.test(subset(ClusterData, Year==1)$kPF, subset(ClusterData, Year==3)$kPF, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kPF and subset(ClusterData, Year == 3)$kPF
t = -1.2585, df = 345.59, p-value = 0.209
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.39218760  0.08612699
sample estimates:
mean of x mean of y
 5.469697  5.622727

> t.test(subset(ClusterData, Year==1)$kPF, subset(ClusterData, Year==4)$kPF, p.adj="none") #p=0.0
03584, PF is significantly lower for seniors than

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 1)$kPF and subset(ClusterData, Year == 4)$kPF
t = 1.5357, df = 49.859, p-value = 0.1309
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.08211074  0.61525468
sample estimates:
```

```
mean of x mean of y
 5.469697  5.203125

>
> t.test(subset(ClusterData, Year==2)$kPF, subset(ClusterData, Year==3)$kPF, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 2)$kPF and subset(ClusterData, Year == 3)$kPF
t = -0.61758, df = 295.95, p-value = 0.5373
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.2774730  0.1449217
sample estimates:
mean of x mean of y
 5.556452  5.622727

> t.test(subset(ClusterData, Year==2)$kPF, subset(ClusterData, Year==4)$kPF, p.adj="none") #p=0.0
0537, PF is significantly lower for seniors than sophomore

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 2)$kPF and subset(ClusterData, Year == 4)$kPF
t = 2.1557, df = 40.035, p-value = 0.03717
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.0220786 0.6845746
sample estimates:
mean of x mean of y
 5.556452  5.203125

>
> t.test(subset(ClusterData, Year==3)$kPF, subset(ClusterData, Year==4)$kPF, p.adj="none") #p=0.0
2428, PF is significantly lower for seniors than junior

	Welch Two Sample t-test

data:  subset(ClusterData, Year == 3)$kPF and subset(ClusterData, Year == 4)$kPF
t = 2.3497, df = 55.235, p-value = 0.02239
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 0.06175784 0.77744670
sample estimates:
mean of x mean of y
 5.622727  5.203125

>
>
> manova_A<-manova(cbind(kPF,kCL,kAL)~as.factor(Asian),data=ClusterData)
> summary(manova_A)
                  Df   Pillai approx F num Df den Df    Pr(>F)
as.factor(Asian)   1 0.029502   7.5188      3    742 5.828e-05 ***
Residuals        744
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
>
> #Can specify which test
```

```
> summary(manova_A, test='Hotelling-Lawley')
                  Df Hotelling-Lawley approx F num Df den Df    Pr(>F)    
as.factor(Asian)   1         0.030399   7.5188      3    742 5.828e-05 ***
Residuals        744                                                      
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> summary(manova_A, test='Roy') #Rencher recommends not using Roy's test in any situation unless there is collinearity amongst the dependent variables (Rencher, n.d., pp. 177-177).
                  Df      Roy approx F num Df den Df    Pr(>F)    
as.factor(Asian)   1 0.030399   7.5188      3    742 5.828e-05 ***
Residuals        744                                              
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> summary(manova_A, test='Pillai')
                  Df   Pillai approx F num Df den Df    Pr(>F)    
as.factor(Asian)   1 0.029502   7.5188      3    742 5.828e-05 ***
Residuals        744                                              
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> summary(manova_A, test='Wilks')
                  Df  Wilks approx F num Df den Df    Pr(>F)    
as.factor(Asian)   1 0.9705   7.5188      3    742 5.828e-05 ***
Residuals        744                                            
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
> #RESULTS: All tests are significant
> 
> t.test(subset(ClusterData, Asian==1)$kCL, subset(ClusterData, Asian==0)$kCL, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Asian == 1)$kCL and subset(ClusterData, Asian == 0)$kCL
t = -2.2554, df = 95.429, p-value = 0.02639
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.69879545 -0.04454427
sample estimates:
mean of x mean of y 
 3.934177  4.305847 

> t.test(subset(ClusterData, Asian==1)$kAL, subset(ClusterData, Asian==0)$kAL, p.adj="none")

	Welch Two Sample t-test

data:  subset(ClusterData, Asian == 1)$kAL and subset(ClusterData, Asian == 0)$kAL
t = -4.57, df = 96.371, p-value = 1.446e-05
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.8000312 -0.3155186
sample estimates:
mean of x mean of y 
 4.656118  5.213893 

> t.test(subset(ClusterData, Asian==1)$kPF, subset(ClusterData, Asian==0)$kPF, p.adj="none")

	Welch Two Sample t-test
```

```
data:  subset(ClusterData, Asian == 1)$kPF and subset(ClusterData, Asian == 0)$kPF
t = -2.9208, df = 96.146, p-value = 0.00435
alternative hypothesis: true difference in means is not equal to 0
95 percent confidence interval:
 -0.6514766 -0.1242810
sample estimates:
mean of x mean of y
 5.186709  5.574588
```

Appendix O Feedback to Instructors

Engineering Undergraduate's Motivations for Being in Engineering: Future Career Perceptions

A Report of Results by Catherine McGough to [Instructor] on
[Name of Course]

This report presents results from the survey distributed in [Instructor]'s [Course Name] class. The results from this class will be included in the data for the larger study described in the Project Summary.

Overview of Results
The results from the survey show that one third (33%) of the students in [Course] have a specific future career in engineering that they are working towards; this group of students are finding the information they are learning [Course] to be useful for their future. About one third (35%) of students have a future goal in engineering, but do not believe they will be able to achieve it; nonetheless, this group finds their grade in [Course]to be important to reaching that goal. And about one third (32%) do not have a specific future career goal and are in engineering because of the breadth of jobs it will prepare them for. These students do not find the class material or their class grade in ELEN 242 particularly useful for their future.

Project Summary

The purpose of this study is to identify a population of undergraduate engineering students in large enrollment classes with a different distribution of characteristic future time perspectives (FTPs) than the norm within their major, describe how this population of students approaches ill-structured problems, and explain how this population of students' FTP relate to how they approach ill-structured problems. I seek to answer the research question, "How does the problem solving approaches of undergraduate engineering students in large enrollment classes with different perceptions of the future than the norm within their major relate to their different perceptions of the future?" This can inform instructors of large enrollment classes how to encourage students with different ways of thinking to persist in engineering.

I will quantitatively identify a group of students with different ways of perceiving the future, and qualitatively explore how they perceive the future. The ways students perceive the future will be based on previously determined characteristic types of Future Time Perspectives (FTP). FTP is the personal and individual way of thinking about the future—the future goals and how those goals affect their future.

Understanding how FTPs affect problem solving skills of students will help instructors know where to focus their attention when teaching students to solve ill-structured problems such as those they will encounter after graduation. I will share the results of this study so engineering instructors can use the FTP survey to understand their students' FTPs and adjust their instruction appropriately. This will be particularly valuable in large enrollment engineering programs where class sizes are large and professors may not have opportunities to gain insight into their students' motivations and goals.

Survey Measured Seven Constructs that Together Describe Students' Beliefs about the Future

Table 1 contains a list of constructs on the survey and what a high score on that construct indicates[1-3]:

Table 1: Constructs of The Students' Future Goals Measured on the Survey		
1	**Clarity of Future Goals**	The student has a well-defined future goal, deep into the future.
2	**Value of the Future**	The student believes that setting goals deep into the future is valuable.
3	**Perceptions of the Future in Engineering**	The student is certain about being an engineer.
4	**Effect of the Future on the Present**	The student recognizes that their future goals affect what they do in the present.
5	**Exogenous Perceived Instrumentality**	The student finds their class grade to be useful for their future career.
6	**Endogenous Perceived Instrumentality**	The student finds their class useful for their future career.
7	**Time Attitude towards the Future**	The student has a positive view about their future possibilities.

Resulting Groups are Consistent with Previous Research

A k-means cluster analysis was implemented with data collected from three institutions (N=416) to identify groups of students with similar beliefs about the future. K-means cluster analysis is appropriate for large sample sizes where the number of clusters (k=3) is hypothesized based on theory or previous studies[4-6]. The cluster analysis resulted in three groups with means consistent with previous research[3,7,8]. To visualize these groups, a cone analogy is used (Figure 1).

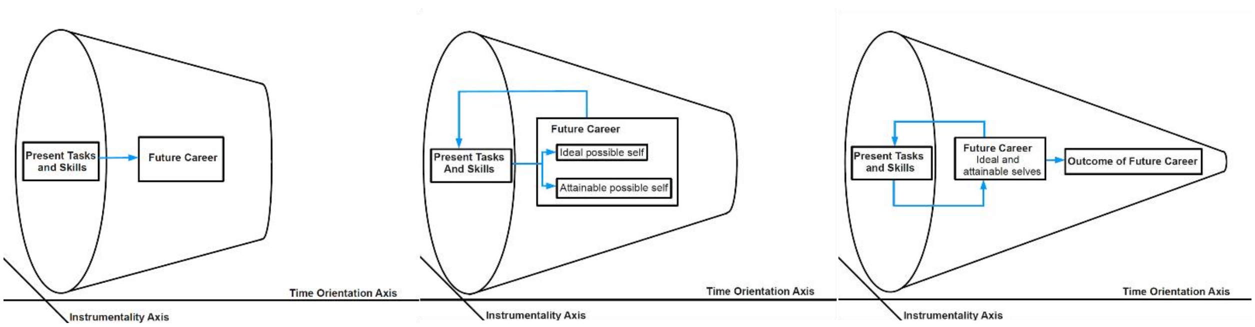


Figure 1: Cake (left) has a shorter and wider cone, representative of their shorter extension into the future; Sugar (right) has high clarity (one goal deep into the future), represented by the long pointy cone shape; and Waffle (middle) has a medium cone width and depth compared to the Cake and Sugar[9].

What These Groups Look Like in ELEN 242

Based on the results from the survey and descriptions from previous research[7,10,11], the different groups in ELEN 242 are shown in Table 2 and described on the next page:

Sugar: One third of the class (33%) has well-defined future goals. These students know what they want to be up to 10 years in the future (*clarity of future goals*) in engineering (*perception of future in engineering*). These students believe they can achieve their goal (*future time attitude)*, and are motivated to work in your class because of their future goals (*perceived instrumentality and effect of future on present*). Their high *endogenous perceived*

instrumentality means that you are effectively connecting what they are learning in the class to their future goals. The lower *exogenous perceived instrumentality* indicates that they are not as motivated by their grades.

Waffle: Slightly over one third of the class (35%) has a more negative outlook of the future (*future time attitude*). These students have a moderately well-defined goal after graduation (*clarity of future goals)*, but they do not think they will be able to achieve this goal, most likely due to not having high enough grades, which is making the grade in this class important for their future goals (*Exogenous Perceived Instrumentality)*. The low endogenous and high exogenous perceived instrumentality indicate that these students are not as focused on the content as they are with grade they will receive.

Cake: 32% of the students in the class have a more broad conception of the future, and are not thinking past their first job after graduation (*clarity of future goals*). They are most likely in engineering because of the wide range of future careers it allows (*future in engineering*); in other words, all things are still possible (*future time attitude*). Typically these students have a high endogenous perceived instrumentality; because of these wide range of possible goals, any information they learn could be relevant to their future. But in this class, the students in the *Sugar* are finding the information in the class more relevant to their future.

Table 2: Construct Means for Each Group in ELEN 242

	Cake	Sugar	Waffle
Percent of Sample	32%	33%	35%
Clarity of Future Goals	↓	↑	–
Value of the Future	↓	↑	–
Perception of Future in Engineering	↓	↑	–
Effect of the Future on the Present	↓	–	↑
Exogenous Perceived Instrumentality	–	–	↑
Endogenous Perceived Instrumentality	–	↑	↓
Time Attitude of the Future	–	↑	↓

Note: ↑ indicates the group with the highest score on a construct, ↓ the lowest score on a construct, and – the medium score.

Implications for Instruction in ELEN 242

The end of the semester is approaching soon, and tasks in your class are likely getting more difficult. Students' beliefs are increasingly important for their success on difficult tasks. The belief that difficult tasks are important as well as the belief that the future is valuable is correlated to higher academic achievement and persistence[12,13]. The students who are motivated by their future goals (Sugar) are finding the course material important for their future, and believe that the future is valuable. For those students who are more focused on the present (Cake and Waffle), you need to connect the future to the "now" to motivate the students to learn and understand the material (*endogenous perceived instrumentality*).

There are many ways to help connect your students' future to their present by adjusting the language you use in your classroom. Talking about the future as a path, and speaking of the future as "near" rather than "far" can help students see the value of the future by connecting it to the present. Also,

using smaller time units (days vs. years) makes the future seem more connected to the right now[14] (i.e. "You will use this in your classes sophomore year, in 121 days." Or "You may see this in your first job after graduation, which is in 1095 days.").

Sample is Representative of National Averages

The students who consented to participate in the survey in ELEN 242 (N=54) are included in this analysis (Table 3). The sample is representative of the national undergraduate engineering population according to race, gender, and residency as shown in Table 4.

Table 3: Sample Size			
Students in ELEN 242	**Students who Responded**	**Students who Consented to Participate**	**Response Rate**
58	54	54	93%

Table 4: Demographics for ELEN 242 and Nationally				
	White	**Male**	**Heterosexual**	**Born in US**
ELEN 242	78%	74%	98%	91%
National Undergraduate Engineering Population(Yoder, 2012)	64%	81%	NA	91%

Note: To determine that the survey is reliable for this sample, a maximum likelihood factor analysis using promax rotation was used[1-3,7,16-20]. Cronbach's alphas for all of the constructs were sufficiently high (>.6)[21].

Future Work

This information is intended to inform you of the different ways students in your class are thinking about their future careers in engineering. I encourage you to use this information to appeal to your students' attitudes and beliefs through your instruction. Future work for this study will include results on how these different groups are approaching problems. I will continue to update you with results from this study. Until then, please feel free to contact me with any questions.

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Appendix P Reflection for Students to Connect Goals in a Course to Long-Term Goals

Connection Between Short-Term Goals in this Course and Long-Term Goals

Date:________________ Name:_____________

Starting thinking about and writing about your goals for this course. Start by going beyond the scope of this course to your own long-term goals (i.e. career goals or personal goals after graduation).

Are your long-term goals driving your goals in this course? If so, how?

How do you see this competency helping you work towards your long-term goals?