WHAT'S THE 'PROBLEM' STATEMENT? AN INVESTIGATION OF PROBLEM-BASED WRITING IN A FIRST YEAR ENGINEERING PROGRAM

by

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To all the little Black girls with big dreams.

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ABSTRACT

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Conceptualizations of *effective communication* vary across contexts and are largely dependent on the needs and social practices of communities. As a global field of study and practice, Engineering is but one community where researchers and practitioners have come together to unpack and conceptualize what it means to communicate effectively, largely in response to the Accrediting Board of Engineering and Technology (ABET) student learning outcome: *an ability to communicate effectively*. Focusing on a specialized sub-genre, the problem statement, this dissertation explores the communicative practices of students enrolled in a First Year Engineering program at a large Mid-west, STEM-focused university and faculty perceptions of students' writing skills and communication strategies. Specifically, this research observes the recurrent rhetorical practices of first year engineering students through an ESP lens for genre analysis, investigates the recurrent instances of language observed in students' texts, and explores faculty perceptions of effective communication in order to: (1) understand what impacts faculty perceptions of effective communication, (2) identify the expected rhetorical moves and steps of problem statements; (3) identify formulaic language that occurs with the expected rhetorical moves and steps for problem statements; and (4) explore possible interactions between the language choices students make and the pedagogical materials used to teaching writing in first year engineering.

A corpus of 1,192 texts consisting of three assignments written by a total of 1,736 first year engineering students was compiled, and 117 pedagogical materials were collected. Using an iterative quantitative-qualitative approach to written discourse analysis, instances of formulaic language (4- and 6-word sequences) were identified in the corpus; formulaic language was then coded for the rhetorical functions expected in problem statements as qualitatively identified in the pedagogical materials. Additionally, three discourse-based interviews were conducted with FYE faculty. Interview data was coded for themes of effective communication and used to triangulate the findings from corpus analysis.

Findings from the interview indicate that there are nine interconnected characteristics that influence faculty perceptions of students' texts: (1) Audience Awareness, (2) Specificity of Content & Data, (3) Organization, Structure, & Logical Flow, (4) Reflective Writing Strategies, (5) Vocabulary & Discipline-specific Meanings, (6) Impact of Pedagogical Materials, (7) Clarity & Conciseness, (8) Genre Conventions & Formality, (9) Mechanics, Grammar, Punctuation, & Syntax. Findings from the corpus-based analysis indicated that students' lexical proficiency of vocabulary and phrases with discipline-specific meanings influences students' genre knowledge development. Additionally, students' development of procedural knowledge and conceptual knowledge of engineering practices may benefit from explicit instruction that supports genre knowledge development for writing problem statements.

CHAPTER 1. INTRODUCTION

1.1 Motivation for the Study

My interest in exploring the genre conventions of problem statements and investigating FYE faculty perceptions of *effective communication* began as a first-year writing instructor for the Global Engineering Learning Community; specifically, I taught the international section of a first-year writing course where all 20 of my students were enrolled in the First Year Engineering (FYE) program at a large Mid-west STEM-focused institution. In addition to being enrolled in my course, and the first sequence of two courses for FYE (e.g., ENGR 131), students were also enrolled in several other courses together including, math, physics, computer science, and communication courses. As one of the FYE programs in the U.S., FYE is a unique educational context in which prospective engineering students are socialized to think, act, and communicate as engineers before they choose their respective specialized degrees (i.e., civil engineering, aeronautical engineering, mechanical engineering, electrical engineering, etc.). All instructors, including myself and the ENGR 131 instructor, participating in the Learning Community met prior to the beginning of the semester and a handful of times throughout. As a previous IEP (Intensive English Program) instructor, I had experience collaborating across and within similar programs where instructors developed materials and discussed learning outcomes and assessment for the same students, and I had expectations that this Learning Community would more or less be the same. While we did meet and discuss outcomes, we primarily focused on building a community of learning for students; we planned field trips, game nights, study sessions, and held tutoring hours. We did not, however, discuss the core curriculum and any expectations for how each instructor would help students develop the key foundational skills needed to be successful in FYE and beyond, including their communication skills.

While the ENGR 131 instructor had upwards of 120 students in her section, both domestic and international students, I had 20 international and self-identified multilingual students. As an eager graduate teaching assistant, I sought to build a writing syllabus that would familiarize students with writing and communicating in engineering at the content level. My syllabus included a collaborative research project where students were asked to develop research questions related to engineering and write a sequence of assignments: an annotated bibliography, a research proposal, weekly memo reports, survey questions, data analysis reports, and, finally, a research paper. Some of the students were familiar with the genre conventions of annotated bibliographies and expository research papers, but the majority (as I anticipated), had never written or encountered the other genres. As we approached the research proposal, I asked students to write a problem statement. My expectation was that students would consider their potential audiences, the context for their research, the "why this problem is important," and the benefits of their research. As I tend to do, I provided students with models of successful research proposals with problem statements; one of our in-class activities was a genre analysis where I asked students to identify the various moves and steps that were similar across the examples and to discuss how these conventions impact readers' experiences. I also asked students to notice any linguistic patterns between the texts, and how the writers achieve certain moves (e.g., introducing a problem). As students turned in their first and second drafts, I noticed that, unlike with previous courses where I taught a similar assignment using the same genre analysis approach, my FYE students were having a particularly difficult time with the problem statement. What I did not know until later was that, concurrent to my teaching problem statements, students were also being introduced and taught to write problem statements in ENGR 131.

After scheduling a meeting with the ENGR 131 instructor, I quickly realized that problem statements are not a 'one size fits all' genre, and that conventions vary according to the context and the discourse community. While we had one thing in common, identifying problems, the function and role of the problem statement in my class and in ENGR 131 were (and are) very different. Rather than being part of a research proposal, problem statements live in other genres including technical reports and technical memos; rather than occurring later in a document like a research proposal, problem statements in FYE are typically seen at the beginning of a document in the introduction. These conventions, and many that this dissertation uncovers, and how students do and do not achieve the expected conventions in FYE impact faculty perceptions of communication. Because I wanted to find ways to support my students' writing development in ENGR 131, I asked the instructor if she had access to other "good" models of problem statements in FYE that the students and I could analyze together, comparing them to the problem statements we were writing in my course; she did not have models. I then sought to use other resources like MISCUP (the Michigan Corpus of Upper-Level Student Papers), to find models of problem statements in similar genres that students in FYE were being asked to write. I was not very successful. Ultimately, my students decided to boycott engineering and asked that we read Stephen King. I obliged my students and found my dissertation topic.

1.2 An Ability to Communicate Effectively: Writing in Engineering

> It's kind of hard, but you know it's acknowledging that in these spaces these [vocabulary]…look like words you can go look up in a dictionary and you can, but they're cultural jargon. **Normal people don't talk [or write] that way**.

The quote above is an excerpt from an interview with one of my participants, Dr. Robins. What is interesting about Dr. Robins is that much of her focus on effective communication skills

emphasized the role of vocabulary and her place of tension as a multi-disciplinary scholar and teacher. On one hand, she recognizes engineering as a discipline with a unique culture, and with culture comes language; on the other hand, she also recognizes that first-year students will have a particularly difficult time learning vocabulary that carry a wide range of discipline-specific meanings. Much of her dissatisfaction with students' writing, as I will demonstrate in chapter 4, comes from realizing that students, and those without the same level of discipline-specific knowledge that comes with years of training and socialization, do not understand the relationship between the conceptual and procedural knowledges they are expected to learn and demonstrate in their writing and the fluidity of language and meaning across contexts. The vocabulary that Dr. Robins is referring to in this quote are terms that students are often expected to use when they write problem statements (e.g., *clients, needs, criteria, constraints, limitations, assumptions,* and *trade-offs*). Dr. Robins' focus on language with discipline-specific meanings peaked my interest because while much of the research on effective communication and writing in engineering has focused on how to increase industry employers' satisfaction with the writing skills of new hires (Berthouex, 1996; Hirsch et al., 2005; Male, Bush, & Chapman, 2010; Howard, Khosronejad, & Calvo, 2017; Reave, 2004; Sageev & Romanowski, 2001), these skills often refer to broader concepts than lexical proficiency: audience awareness, clarity and conciseness, and technically appropriate texts. Writing studies research in engineering, outside of ESP (English for Specific Purposes), has not fully explored the role that vocabulary has on faculty perceptions of effective communication. Coxhead (2013) highlights the critical role vocabulary has on second language learners' socialization process of *belonging* to a group, or discourse community. Unlike in other undergraduate courses, FYE is unique because the

program is focused on socializing both domestic and international students to think, act, and write like engineers; vocabulary is just one skill that can influence the socialization process.

Although scholars and practitioners ubiquitously agree that writing is a necessary and vital skill for successful engineers, Howard, Khosronejad, and Calvo (2017) point out that there is little in the way of research on how engineering faculty perceive and practice writing in their classrooms. In general, however, writing is seen as a useful tool for learning new knowledge and demonstrating disciplinary socialization (Wheeler & McDonald, 2000). Perhaps because writing is a central practice to engineering, communication, both in industry and in academia, takes place in a variety of forms including grants, technical briefs, design reports, presentations, memorandums, etc. Engineers are not only expected to produce technically accurate and appropriate documents and designs, but they are also required to be able to communicate the nuances of their documents, which often are inundated with discipline-specific information and knowledge, to a global audience (Troy, et al, 2014). The communication skills that undergraduate students acquire during their matriculation are heavily informed by the Accrediting Board of Engineering and Technology (ABET) requirements for accreditation. The ABET, a non-profit and non-governmental accrediting agency, ensures that colleges and universities equip graduates with the necessary knowledge and skills of the profession (www.abet.org). Educational programs in STEM, such as the First Year Engineering (FYE) program which is the research site for this dissertation, have emphasized assessment of student learning outcomes such as “an ability to communicate effectively” without an operationalization of what it *means* to communicate effectively in engineering. While the ABET does list 10 distinct student learning outcomes, as will be outlined in chapter 2, the focus of this dissertation is on the seventh student learning outcome: an ability to communicate effectively. With the

emphasis on product and not process, educational programs have flexibility in how they achieve these student learning outcomes; however, there is still much discussion on what it means for an engineer to communicate *effectively* (Howard, Khosronejad, & Cavlo, 2017; Moore & Morton, 2017) and a general understanding that teaching effective writing strategies will require interdisciplinary partnerships between writing programs and engineering programs (Kuhn & Vaught-Alexander, 1994; Leydens & Schneider, 2009; Wheeler & McDonald, 2000).

While *effective communication* is a nebulous concept that is context-dependent, research demonstrates that communication, regardless of register (spoken or written), is largely dependent on discourse community knowledge, conceptual knowledge, rhetorical knowledge, linguistic knowledge, genre knowledge, subject matter knowledge, and [writing] process knowledge (Bazerman, 1988; Beaufort, 2012, 2008; Conrad, 2018, 2017; Swales, 1990; Tardy 2009; Winsor, 1990). These knowledges, how they are defined and developed, are deeply dependent upon a community's social and practical needs and the activities with which they are engaged. FYE introduces first-year students to the foundational skills and knowledges (i.e., design process, project management, logical thinking, use of modern engineering tools, etc.) necessary for students to be successful as they matriculate through their respective disciplines (i.e., aeronautical engineering, chemical engineering, civil engineering, etc.). To assess students' conceptual and procedural knowledge development, FYE uses a series of problem-based and project-based writing assignments and tasks. Two of the genres for these assignments are technical briefs and technical reports, and each of these genres include a problem statement. These genres are thus used as products for assessing how students achieve learning outcomes as prescribed by the ABET and the first year engineering curriculum development team.

Research on effective communication in engineering tends to focus on individually written texts and predominately on L1 English writers. In first year engineering, however, students are assigned to groups of three to four and required to collaborate in these groups for the entire semester on various tasks, including written assignments; this decision to place students in groups for the semester likely mirrors industry interest in promoting collaboration and intercultural awareness. Interestingly, these groups are intended to be linguistically, racially, and ethnically diverse. Intercultural awareness and engagement are important to first year engineering, reflecting the internationalization of the field (Brunhaver, Korte, Lande, & Sheppard, 2010; Jesiek, Shen, & Haller, 2012; Mayhew, Eljamal, Dey, & Pang, 2005). This undoubtedly creates a need for research on how multilingual writers engage in and achieve effective communication in first year engineering, and what best pedagogical practices adequately address the needs of both L1 and L2 students.

When investigating the factors of effective communication, it is essential that we consider students' linguistic backgrounds and various proficiency levels as they engage with the writing process, especially observing the linguistic, discourse community, and genre knowledges that students bring with them as they engage in collaborative tasks. Research in applied linguistics has demonstrated that linguistic knowledge and proficiency levels shape communication strategies between interlocutors (McCutchen, 1986; Nobuyoshi & Ellis, 1993; Shehadeh, 2003). Particularly if we consider theories and application of communicative competence, as it relates to second language learning, such as communicative language teaching (CLT), we see an emphasis placed on effective functionality in different environments and situations (Savignon, 2018). CLT is the realization of applied linguists that mere mastery of grammatical forms and structures is inadequate when preparing students to communicate

effectively and appropriately within any given *context of situation*, or physical environment within which a linguistic activity is performed (Berns, 1983). While many theorists and practitioners apply CLT to oral communication, communicative principles are equally applicable to writing (and reading) tasks where interlocutors and writers/readers are engaged in the *expression*, *interpretation*, and *negotiation* of *meaning* (Savignon, 2018). One driving force of CLT is shaping the goals of learning by conducting a needs analysis of learners and acknowledging that learners' needs are context-dependent – context informs the appropriacy and norms of linguistic usage, thus, informing which communicative strategies are most effective for students to learn in order to function within any given situation. Communicative competence views communication as an interwoven relationship between both linguistic insights and sociological factors. One step towards assessing students' needs in a context such as first year engineering is exploring the writing strategies both L1 and L2 writers employ when engaging in authentic language acts, such as context-specific genres as problem statements, and investigating the communicative effectiveness of those strategies with insider perspectives via interviews.

1.3 Problem Statements and Effective Communication in First Year Engineering

One small step towards unpacking what constitutes *effective communication* in first year engineering and understanding the writing instruction needs of both L1 and L2 writers is investigating the writing strategies they employ in a recurrent rhetorical move: problem statements. Problem statements in FYE are a highly specialized genre that are used as a metric to assess students' ability to effectively communicate complex conceptual and procedural knowledge. Throughout the semester students are assigned a variety of written tasks and approximately 90% of these genres include a problem statement component. Because students are expected to communicate specific information important to their design decisions in their

problem statements, one approach to investigating strategies of effective communication is identifying the most commonly recurrent multi-word formulaic sequences specific to this discipline. Further, understanding how the most commonly recurrent multi-word formulaic sequences function provides insight on the most in/effective communication strategies used by both L1 and L2 students. Importantly, linguistic analyses for this dissertation will be supported with qualitative analysis in the form of discourse-based interviews. Because language is shaped by the context within which it is produced, effective communication needs to be defined by experts in the field, and more specifically by those who assess the standards of learning. It is also worth noting that problem statements, as I will discuss in the literature review, appear to be specific to this research context – there is currently no research on the role and function of problem statements as it relates to engineering.

1.4 Multilingual Writers

One of my interests as a second language writing scholar is exploring best practices for writing instruction that meets the needs of multilingual students, particularly in contexts such as FYE where resources for multilingual, or L2, students may not be readily available, and where L1 students might be observed as "taking over" the writing process. For these reasons, I wanted to be sure to take the time to define what I mean by *multilingual*, especially since students in the context may be multilingual and domestic or international but identify with English as their first and only language.

Terms such as ESL, ELL, and Generation 1.5 are often fraught with assumptions and complications, particularly for resident (domestic) students who may not identify with English as their second or third language, but as their first language (Ortmeier-Hooper, 2008). Not only are these terms complex in regard to students' identities and positionalities, but they often act as

institutional markers, influencing how faculty and staff perceive, assess, and place students, particularly when it comes to writing courses. Interestingly, as will be highlighted in chapter 3, international students in this context often identified English as their first language although coming from countries that we might assume have different first languages; conversely, domestic students in this research at times identified another language other than English as their first language. Because identities are fluid and I was not able to get exact information from students regarding their home language(s), I have adopted the term *multilingual* for those students who are either domestic and identified with another first language other than English and those students who are *international* and identified with English as their first language. I have chosen to use English-only, or L1, for those students who identified as U.S. citizens with English as a first language.

1.5 Research Overview & Research Questions

My brief discussion here on perceptions of effective communication in engineering, CLT and communicative competence, and ABET learning outcomes sets the stage for how I view *language* and the decisions I have made going forward in answering the research questions. As I will outline in my literature view, much of the research exploring writing in engineering focuses on native speakers and generally comes out of subfields of writing studies, such as Writing in the Disciplines (WID) and Writing Across the Curriculum (WAC), and adopts primarily qualitative methods including interviews, case studies, and longitudinal studies. There has been little research that uses a mixed-methods approach with a focus on linguistic analysis of both English-only writers and multi-lingual writers to unpack what constitutes effective communication in

engineering[1]. As such, the ABET and first year engineering student learning outcomes may not account for varying degrees of English and writing proficiencies despite recognizing and promoting engineering as a global and international field; by doing so, they have adopted an assumed position that the only writer is an L1 writer, structuring standards of learning based on native speaker norms. To support both L1 and multilingual writers in developing effective communication and writing skills appropriate for undergraduate engineering, we need to use interdisciplinary methods of inquiry and interdisciplinary methods for teaching.

My research uses an iterative quantitative-qualitative approach to examine the writing practices of FYE students across three assignments that have a problem statement component and their accompanying pedagogical materials: (1) The Airplane Rodeo Assignment, (2) The Net Zero Energy Assignment, and (3) The Final Design Project. I use a corpus-based approach to written discourse analysis wherein I analyze instances of formulaic language in students' texts with qualitative methods for coding the rhetorical functions of formulaic language identified in the corpus. To understand how faculty conceptualize effective communication, I conducted discourse-based interviews with three FYE faculty. Interviews were also used to triangulate my textual analysis findings and understand the genre conventions for problem statements in FYE. The research questions for this dissertation are:

1. Based on faculty perceptions, what constitutes "Effective Communication" in FYE?
2. What are the expected rhetorical generic moves and steps of problem statements in FYE?
3. What formulaic language represent the rhetorical moves and steps of problem statements, as indication in the pedagogical materials and students' texts?

[1] Conrad (2017, 2018) is an example of an applied linguist using mixed-methods to analyze writing strategies in Civil Engineering.

4. Do students use the formulaic language from pedagogical materials across all three assignments?

1.6 Outline of the Study

The first chapter of this dissertation is the introduction. Chapter 2 of my study provides a literature review on previous research on *genre* from two of three traditions: North American New Rhetoric and English for Specific Purposes (ESP), as well as previous research on formulaic language and academic writing conventions. Chapter 2 also describes additional research on effective communication in engineering-specific disciplines and the limited research on problem statements. Chapter 3 provides detailed information for the research design and methods used to answer the research questions. Chapter 4 provides the data analysis, results, and discussion for research question 1, while chapter 5 provides data analysis, results and discussion for research questions two, three, and four. Lastly, chapter 6 provides a key summary of the findings, implications for ESP and genre analysis in FYE writing instruction, and future directions for this research.

CHAPTER 2. LITERATURE REVIEW

2.1 Introduction

In this literature review chapter, I closely examine the role of writing in engineering disciplines, unpacking the ways in which *effective communication* is perceived and defined by industry, scholars, and educators. I further engage with the relationships between language proficiency and knowledge and disciplinary acquisition as understood by scholars in applied linguistics, rhetoric and composition, and English for Specific Purposes (ESP). As this research is descriptive and exploratory by nature, I provide an overview of literature that brings together constructs of knowledge, language, and genre, demonstrating how the three are interconnected, weaving together disciplinary identities into the fabric of writing.

In addition to this, I discuss the importance of recognizing the growing internationalization of STEM fields such as First Year Engineering (FYE), and how this growth impacts current trends in research questions and research methodologies as it relates to discipline-specific writing instruction. I situate the role and purpose of writing in FYE, and stress the importance of how writing instruction in FYE would benefit from faculty and staff deliberately recognizing and engaging with the multifarious needs of both L1 and L2 developing writers given the internationalization of the field. I argue that because the ABET (Accrediting Board of Engineering and Technology) learning outcomes do not account for two things: (1) a clear definition of “effective communication” and (2) a diverse student population. Consequently, FYE is having a difficult time discussing and approaching writing instruction that is effective for both populations of student learners. Additionally, I set the stage for a later discussion on the ways in which WID and ESP frameworks of genre analysis would benefit from

engaging in methodological conversations to researching and informing writing in the disciplines.

2.2 Linguistic Diversity and the Internationalization of STEM

In fall 2017, Purdue University was ranked 3rd for international student enrollment at U.S. public universities and 2nd in the big ten (Purdue University, 2017). According to Purdue University Data Digest, the total undergraduate enrollment for 2017 was 31,006, 75% of all enrollment, including graduate and professional students. Of the 31,006 students enrolled, 16% (n = 4,933) were international students. Of the 31,006 total students enrolled, 33% (n = 10,193) were newly enrolled freshmen out of which 18% (n = 1,871) were international students. Of the total number of students enrolled at Purdue, 26% (n = 8,606) were enrolled in the College of Engineering out of which 21% (n = 1,777) were international students. The percentage of international students enrolling at Purdue has remained rather consistent over the last eight years, a statistic that possibly supports the steady internationalization of STEM fields. The internationalization of STEM fields such as First Year Engineering (FYE) reflects an increase in the linguistic diversity observed in undergraduate classrooms across the American university campus. I note this increase in linguistic diversity for two reasons specific to the research context, FYE: (1) as the demographics of the student population change, how faculty and administration assess and meet the needs of learners and the learning outcomes they establish should reflect these demographic changes, and (2) much of FYE's current curricular structure fosters collaborative and problem-based learning approaches, which are arguably a reflection of industry and corporate practices; these approaches, however, result in students being intentionally grouped based on their linguistic, cultural, racial, and academic backgrounds so as to provide opportunities for students to engage in cross-cultural communication with diverse audiences. This diversity, specifically

linguistic diversity, undoubtedly influences the ways in which students approach genre-specific writing tasks and the knowledges they bring with them to the classroom, and how they achieve established student learning outcomes. While there is research on the rhetorical writing and communication practices of engineers, both in academia and professional spaces (see Conrad, 2017, 2018; Ford & Riley, 2003; Ford, 2004; Winsor, 1990, 1999; 2013; Gruber, Larson, Scott, & Neville, 1999), there is limited research that explores the and analyzes the linguistic features (e.g., formulaic language) present in FYE students' texts.

More specifically, there is limited research on the genre conventions of problem statements from an engineering perspective, on the pedagogical role and purposes of teaching both domestic and international students how to write problem statements, and on how problem statements help students achieve the ABET's learning outcome "an ability to communicate effectively."

2.2.1 The Accrediting Board of Engineering and Technology and First Year Engineering

The student learning outcomes for FYE are established by The Accrediting Board of Engineering (ABET). FYE engineering serves approximately 2500 students each year, and they have two primary courses: ENGR 131 (fall semester) and ENGR 132 (spring semester). In addition to the ENGR 131-132 sequence, first year students are enrolled in physics, math, chemistry, English, and other communication courses (see First-Year Engineering at Purdue). As the first of the two sequences for FYE, ENGR 131 introduces students to the design process of engineering by building students' content knowledge of engineering through multidisciplinary approaches and collaborative learning. This introductory course is intended to develop students' skills in project management, engineering fundamentals, oral and graphic communication, logical thinking, and use of modern engineering tools. To develop these essential skills, students are given complex

problems and asked to respond to and provide solutions for a perceived client, user, and/or stakeholder. The problems that students are asked to tackle are often diverse in the scope of issues they address, ranging from global to local concerns (i.e., addressing Amazon's recycling issues to helping manage waste at refugee camps). The curriculum for this course has been shaped to meet ABET's requirements for accreditation.

ABET is "a nonprofit, non-governmental accrediting agency for programs in applied and natural science, computing, engineering, and engineering technology" and they provide "assurance that a college or university program meets the quality standards of the profession for which that program prepares graduates" (www.abet.org). Rather than continuing to center student learning outcomes and accreditation requirements on what is taught, ABET has shifted its focus to what is learned, providing accreditation seeking programs with flexibility in how they achieve these outcomes (see Slagely & Smith, 2008). Abel and Fernandez (2005) elucidate the Engineering Criteria 2000 (EC2000) initiative:

> The ABET 2000 accreditation criteria focus on the identification of program constituencies and their needs, the definition of program objectives based on these needs, the creation of mechanisms for meeting these objectives, the measurement of outcomes related to these objectives, and a feedback loop providing continuous process improvement. (p.6)

According to Slagley and Smith (2008), "The ABET process is focused on quality, requiring metrics be collected to ensure that the educational programs meet their outcome goals, and ultimately the needs of the customers" (p. 2). Customers of college programs, as Slagley and Smith highlight, include both internal (students and the faculty and their research) and external (industry employers of future graduates). Among the criteria for accrediting engineering

programs nationwide to meet the needs of customers is an emphasis on student outcomes. The ABET defines *student outcomes* as a description of what "students are expected to know and be able to do by the time of graduation. These relate to the knowledge, skills, and behaviors that students acquire as they progress through the program" (www.abet.org). There are 10 student outcomes that the ABET requires programs seeking accreditation to document, not including any additional outcomes as determined by the program seeking accreditation. The 10 student outcomes are as follows:

(a) an ability to apply knowledge of mathematics, science, and engineering;

(b) an ability to design and conduct experiments, as well as to analyze and interpret data;

(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability;

(d) an ability to function on multidisciplinary teams;

(e) an ability to identify, formulate, and solve engineering problems;

(f) an understanding of professional and ethical responsibility;

(g) an ability to communicate effectively;

(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context;

(i) a recognition of the need for, and an ability to engage in life-long learning;

(j) a knowledge of contemporary issues;

(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

As I will reiterate in my research design and methods chapter, ENGR 131 engages with nine of the eleven student objectives above, with an emphasis on (1) an ability to design and conduct experiments, as well as to analyze and interpret data; (2) an ability to function on multidisciplinary teams; (3) an ability to communicate effectively; and (4) an ability to use techniques, skills, and modern engineering tools necessary for engineering practice.

The student outcome of interest for this research is *(g) an ability to communicate effectively*. I focus on *effective communication* for four reasons: (1) the ABET and the research site for this project have not defined what it means for one to communicate effectively or its relationship to writing instruction; (2) qualifying communication as "effective" is context dependent; (3) how effective communication is perceived may influence how pedagogical materials and writing instruction are shaped within a context; and (4) without an adequate understanding of how FYE perceives and understands *effective communication*, it is nearly impossible to accurately assess students' communication skills, including their written assignments.

The EC2000 initiation has led to engineering programs "producing a variety of approaches to teaching communication to engineering students, many of which include a number of collaborative variations between communication departments and engineering departments" (Donnell, Aller, Alley, & Kedrowicz, 2011, p. 2). FYE is but one among the many programs that has responded to the push from ABET and industry to develop students' communication skills. In so doing, FYE has developed curriculum in which ten writing assignments are collaboratively authored throughout the semester. The majority of these assignments involve genres that have problem statements either embedded within them, such as technical reports and technical briefs, or problem statements as isolated, scaffolded tasks. Despite their best efforts, FYE faculty have expressed a need for enhanced writing instruction for their students. Conversely, in order to

provide pedagogical materials aimed at meeting ABET learning outcomes, an operationalization of the construct of "effective communication" requires sufficient attention as does understanding the role and function of problem statements as a tool for teaching effective writing strategies.

2.3 Genre-based Approaches to Writing & Genre Theory

Discipline-driven conceptualizations of effective communication may be realized as epistemological knowledge in practice. One way to investigate the epistemological practices of disciplines is through the genres with which communities of practice produce and interact; genre theory provides insights into the interplay of knowledge, writing, and community practices (see Freedman & Medway 1994; Bazerman, 1988; Miller, 1984). In other words, the genres that communities recurrently use provide insights into the knowledges and practices they value. Genre theory is also rich with possibilities for pedagogical applications wherein students are guided towards membership of a specific discipline, or discourse community, via "*effective* use of established genres within that community (Swales, 1990, p. 81, *emphasis added*). For these reasons, I have selected genre theory as the theoretical framework from which I explore discipline-specific writing and effective communication strategies in FYE. Further, as I will demonstrate, I approach genre theory primarily from the ESP perspective, albeit with significant input from the North American New Rhetoric perspective as I believe the best approach to understanding multilingual writing and linguistic diversity in university settings requires an on-going, interdisciplinary conversation.

There are three distinct traditions associated with genre theory: Northern American New Rhetoric, international ESP (English for Specific Purposes), and the Australian School of Systemic-Functional Linguistics (SFL); I will provide a brief overview for the first two: New Rhetoric and ESP, paying particular attention to how the audiences and subscribers of these two

traditions speak to the disparities that exist. Traditionally, New Rhetoric approaches to genre theory have been especially attentive to the situational contexts of genres, emphasizing the actions that genres perform within a given situation rather than on generic forms and conventions of said genres (Hyon, 1996, p. 696). New Rhetoric scholars are generally engaged in more ethnographic-based methods of inquiry where their primary audiences are undergraduate composition students enrolled in a Liberal Arts education program, and often with an emphasis on transfer (see Devitt, 2007; Reiff & Bawarshi, 2011; Smart & Brown, 2004; Sommers & Saltz, 2004; Wardle, 2007). With a focus on the undergraduate writing experience, New Rhetoric scholars are often concerned with a variety of disciplines that focus on L1 writing instruction, placing a strong emphasis on understanding the relationships between texts, writing process, and the sociorhetorical contexts within which texts are produced, and how choices and actions perform certain communicative purposes discipline-specific communities and how genres meet these purposes (see Bazerman, 1988, 2003; Berkenkotter & Huckin, 1995; Campbell & Jamieson, 1978; Dias, Freedman, & Meday, 2013; Jamieson, 1975; Miller, 1984; Spinuzzi, 2003; Yates & Orlikowski, 1992).

Conversely, ESP specialists' primary audiences are EFL and ESL students who are learning languages for professional and academic purposes where genre becomes a tool for teaching both writing and speaking to L2 learners (Cheng, 2006; Cheng, 2008; Bhatia, 1991; Flowerdew, 1993; Hopkins & Dudley-Evans, 1988; Hyon; 1996; Paltridge, 2013; Rahman, 2011; Swales, 1990; Tardy, 2009). Often, ESP approaches to genre implement a *structural move analysis* (see Hyon, 1996) to explicate the structural patterns present in several genres including: experimental research articles (Swales, 1990), lab reports in graduate classrooms (Tardy, 2009), business letters of negotiation (dos Santos, 2002), master of science dissertations (Hopkins &

Dudley-Evans, 1988), medical research papers (Nwogu, 1997), biochemistry research articles (Kanoksilapatham, 2005), discussion sections of research articles (Peacock, 2002), letters of application (Henry & Rosebery, 2001), and research articles in applied linguistics (Ruiying & Allison, 2004). Other scholars have investigated linguistic variation in genres, often using corpus-based approaches, including: hedging strategies in scientific discourse (Varttala, 2001), lexical bundles in history and biology (Cortes, 2004), the variation of modal verbs in the British National Corpus (Kennedy, 2002), the use of metonymy and passive voice in medical discourse (Rundblad, 2007), and personal pronoun use in research article abstracts for financial economics (Ning, 2008).

While there are fairly substantial differences between these two camps of genre theory (e.g., L1 vs L2 instruction, global vs local written concerns, methodological approaches to research and teaching), scholars generally agree that students require a repertoire of situationally appropriate knowledge to recurrent situations (see Berkenkotter & Huckin, 1995). Genre-based approaches to teaching, thus, provide opportunities for students to develop relevant, applicable genre knowledge across and within disciplines. The teaching of genres is closely linked with the activities of a community using them (Bergquist & Ljungber, 1999), and, thus, an effective method of delivering discipline-specific knowledge as well as written knowledge.

2.3.1 Defining Genre

In her 1984 article, Carolyn Miller unpacks the social exigence of genres. Her argument, from a New Rhetoric perspective, situates *genre* as recurrent rhetorical action that reveals the theoretical importance of everyday discourse as recurrent actions expose the human condition. Genres are thus “typified rhetorical actions” that manifest a result of recurrent situations (Miller, 1984, p. 159). Miller (1984) further identifies five features of genres:

1. Genre refers to a conventional category of discourse based in large-scale typification of rhetorical action; as action, it acquires meaning from situation and from the social context in which that situation arose.
2. As meaningful action, genre is interpretable by means of rules; genre rules occur at a relatively high level of a hierarchy of rules for symbolic interaction.
3. Genre is distinct from form: form is the more general term used at all levels of the hierarchy. Genre is a form at one particularly level that is a fusion of lower-level forms and characteristic substance.
4. Genre serves as the substance of forms at higher levels; as recurrent patterns of language use, genres help constitute the substance of our cultural life.
5. A genre is a rhetorical means for mediating private intentions and social exigence; it motivates by connecting private with the public, the singular with the recurrent. (p. 163)

While some scholars may argue that genres are static and an insufficient (and rigid) means of teaching writing, Miller suggests the opposite: based on the context, genres are subject to change and even decay (p. 163).

Much like Miller, Johns (2002), a linguistics scholar, views genre as a marker of the complexity of oral and written utterances by interlocutors who are responding "to the demands of a social context" (p. 3). The complexity of the relationship(s) between writers, readers, texts, and social conditions and expectations makes it implausible to "determine what is an 'appropriate' or 'effective' text in any discourse community or discipline without first considering the social and intellectual activity which the text is part of" (Bazerman, 1988, p. 4). Thus, the social aspect of genre asks us to critically engage the following questions:

1. How is communication organized?
2. How do writers and readers engage with disciplinary activity?
3. How is knowledge acquired and shaped?
4. How is knowledge reflected in genres?
5. How do language and content jointly reflect generic conventions?
6. How do writers choose to engage with generic conventions expected of them?
7. How is meaning is shaped?
8. What knowledges are necessary to understand the meaning(s) of a text?

These questions, and their context-dependent answers, urge scholars and educators to consider how people create texts, why they create texts, and how the texts are used. While writing is often observed as an individual activity, it is thus apparent that writers and their texts are shaped by these complex interactions of social, institutional, and historical forces (see Starfield, 2011; Bakhtin, 2010; Clark & Ivanič, 1997; Hyland 2003; Christie & Martin, 2005; Bhatia, 2004). In other words, as Flowerdew (2011) remarks, genres are multifaceted constructs that are characteristic of the communities of practices, power relations, texts, and inter texts from which genres emerge.

A significant factor for genres, that scholars from multidisciplinary perspectives can agree upon, then, are the purposes communities of practice establish and maintain through recurrent textual patterns employed by discourse communities. Swales (1987) began unpacking what discourse communities entail by examining the concept of discourse community alongside speech community (see Braithwaite, 1984 for a discussion on speech community) from three primary perspectives: shared linguistic rules, shared patterned regularities, and shared cultural

knowledge (pp. 1-2). He determined that a discourse community, which can entail both writing and speaking, has the following characteristics:

1. community of interest,
2. mechanisms for intercommunication between members,
3. survival by providing information and feedback,
4. *development of genre-specific discoursal expectations*,
5. possession of an embedded dynamic towards an increasingly shared and specialized terminology, and
6. a critical mass of members with a suitable degree of relevant discoursal and content expertise. (Swales, 1987, pp. 4-6 *emphasis added*)

Swales (1988) later claims that genres are properties of discourse communities. In other words, genres are the purposes of communities of practice as manifested in the recurrent texts that discourse communities employ. Recurrent patterns, thus, become the object of interest for many genre scholars. Flowerdew (2011) for instance, echoes Swales' research on genre analysis by considering the importance of observing the moves and steps that systematically comprise genres (p. 121), while also reiterating Miller's argument that genres are not static, but fluid and that these steps and moves can appear in a multitude of sequences or not at all.

2.3.2 Genre Knowledge, Disciplinary Knowledge, and Effective Communication

Scholars and teachers have sought out effective methods for teaching academic writing from a genre framework that address a plethora of needs, including accreditation, assessment, outcomes, and transfer (Beaufort, 2012; Driscoll & Wells, 2012; Elton, 2010; Gere, Aull, Escudero, Lancaster, Z., & Lei, 2013; Harrington, Malencyzk, Peckham, Rhodes, & Yancey, 2001; Rounsaville, Goldberg, & Bawarshi, 2008; Wardle, 2009). A genre-based approach is just one

such method of teaching academic writing. Genre-based approaches to teaching academic writing provide teachers and students with valuable tools to analyze the purposes of texts as connected to socio-rhetorical situations and how texts function as vehicles of knowledge and information within and across communities, making explicit connections between social practices, conventions, expectations, and textual functions (Rieff & Barwashi, 2011). In addition to understanding the social function of texts, genre-based approaches to teaching provide an opportunity for students and teachers to engage in explicit conversations on the function of language in fulfilling social and generic expectations (Hyland, 2003). These explicit conversations lead to students making choices that "represent effective ways of getting things done in familiar contexts" (Hyland, 2003, p. 22); inevitably, these conversations lead to students acquiring genre knowledge. For sure, the approach an instructor takes to genre is context-dependent: in a first-year writing class students are likely to be exposed to a plethora of genres including: narratives, rhetorical analyses, research proposals, expository essays, annotated bibliographies, research reports, and various digital genres. In other contexts, however, graduate students from a variety of disciplines may participate in a class specifically for learning to write effective research article literature reviews or PhD dissertations. Multilingual and second language users of English may be in ESP courses specifically for medical professionals or business professionals where they are exposed to generic conventions and specialized language of their target professions. Experts in fields outside of writing studies and applied linguistics within higher education are also appealing to curricular innovations that build communities of practice through developing genre knowledge. O'Neil (2001) argues:

> Writing in a disciplinary genre entails the deliberate use of a community's customs to serve one's own goals of persuasion in a particular situation…genre knowledge is a

> communal form of intellectual property [and] mastering it is an important part of joining a new intellectual community. (pp. 225-226)

Describing the influence of complex social factors, then, is an interdisciplinary concern, particularly when grappling with *how* and *why* to teach certain genres and assignments in an undergraduate context and how to build access to knowledge for students as they matriculate through the academy. Specifically, scholars examine the knowledges that students need to be successful in higher education, while also grappling with where the disciplinary responsibilities lie for teaching these knowledges, particularly for writing instruction.

Beaufort (2008) argues that in order to evolve into an expert writer, five knowledge domains need to be acquired: subject matter knowledge, discourse community knowledge, writing process knowledge, rhetorical knowledge, and *genre knowledge* (pp. 182-183, *emphasis added*). Beaufort's discussion of knowledges, however, appears to treat them discretely – as entities that are acquired and assessed independently. Additionally, when considering the relationship between genre, knowledge, and language, Beaufort fails to define how she conceptualizes *language*. It is inferred from her analyses that *language* here focuses on the rhetorical awareness of audience and context rather than the communicative effects of the linguistic resources used. However, Tardy (2009) suggests that these five knowledge domains, especially as they relate to understanding genre, are not discrete and linguistic knowledge should also be considered more explicitly. In other words, students do not develop subject matter knowledge, discourse community knowledge, writing process knowledge, rhetorical knowledge and genre knowledge separately, and they must also understand the relationships between linguistic forms and (rhetorical) meaning. Thus, as I will demonstrate, the social conventions of

communities (and expected knowledges) inform, too, the linguistic choices that writers make as they engage with genres across and within disciplines – whether consciously or not.

ESP perspectives of genre provide insight into how, when, and why language varies across disciplines and genres, leading to context-specific instruction. Scholars such as Pennycook (2010) argue that unless instructors and researchers investigate the contexts and practices from language emerges and is used, we cannot fully understand the role and purposes of language(s). In other words, "Different texts, roles, and contexts...lead to different ways of doing things with language, different ways of joining in on disciplinary and professional conversations" (Paltridge, 2013, p. 354). Knowledge of how genres influence disciplinary communicative events and acts requires that we understand the functions of a genre from the perspective of the user (see Berkenkotter & Huckin, 1995), or in the case of this research, from the perspective of the instructor within the discourse community. Equally as important to understanding the communicative purpose of a discipline-specific genre is understanding that linguistic knowledge is also essential for effective communication, and that rhetorical knowledge alone will not produce effective communication (see Grabe and Kaplan, 1996).

Writing is locally constructed, situated, negotiated, and defined (Dannels, 2002), as is the community's agreed upon knowledge. This relationship between knowledge and effective communication—writing—is further emphasized by Al-Rawas and Easterbrook (1996) in their research exploring the role of communication in software engineering; they argue that "Knowledge acquisition and sharing can only be achieved through *effective communication*…" (p. 1, emphasis added). Writing, texts, and documentation in engineering are used as a prelude to a final object – not necessarily a final *written* product, but an engineer's object of study (see also Winsor, 1998). Engineers' knowledge flows from text to colleague to text to colleague until

agreed upon knowledge has been reached and a text is potentially shared with an outside audience; however, unless that agreed upon knowledge (see Winsor, 1998) is effectively communicated, essential elements of design may be overlooked, omitted, or misunderstood either by inside audience members (e.g., other engineers) or outside audience members (e.g., clients, stakeholders, and users). The text thus becomes the place of negotiation *and* invention as knowledge is developed and then materialized as a final design object. In this way, writing in such a context may be viewed from the Writing to Learn framework, particularly as we consider writing practices as multiple and varied (Bazerman, 2009). Developing genre knowledge, would provide but another access point for students to understand the relationship(s) between text, situations, and communication.

The motivation for this dissertation is to examine how students from multifarious linguistic backgrounds engage with and co-construct a specialized sub-genre, the problem statement; as such, I have chosen to view the knowledges that Beaufort (2008) highlights through the lens of genre theory, much in the way that Tardy (2009) demonstrates, with an deliberate integration between knowledges rather than separating genre form from subject matter, rhetorical goals and context, and procedures (or processes) add. Tardy argues that "form and content are not distinct from issues of rhetorical context or procedures" (Tardy, 2009, p. 23), and that for writers to be able to communicate actively and effectively within a disciplinary discourse community they must develop *genre knowledge* (p. 19). With an emphasis on task over activity, Tardy demonstrates that, as writers become more familiar with genres through repetitious exposure, they build upon their other knowledges. In the case of FYE, students may develop some *form* knowledge of genres when writing in their respective discipline, especially given the pedagogical materials and tasks provided to them, but the primary knowledges that

FYE faculty emphasize in their classrooms are conceptual knowledge and procedural knowledge related to engineering design; these knowledges, conceptual and procedural, may certainly be categorized as rhetorical knowledge, content knowledge, and subject-matter knowledge. The technical genres in FYE, thus, become a vehicle for carrying these knowledges and a tool for instructors to assess students' knowledge development.

Scholars generally agree that genres rarely function alone, but rather "interact with layers of other genres used to accomplish other, related goals" (Tardy, 2009, p. 13). Genres are both impacted by social factors of a discourse community and impact discourse communities' modes and methods of communication. In other words, it is important to investigate the situatedness of genres, to understand the boundaries of the genre imposed by the community, whether that be within or outside the classroom. In thinking about genres and effective communication, I draw on research in Applied Linguistics that highlights the importance of understanding the communicative purposes of texts by particular discourse communities. Flowerdew (2011) maintains that

> Communicative purposes are expressed in a staged or sequenced manner, a text being built up systematically through a series of what are called moves and steps. These moves and steps may be obligatory or optional, may vary in their sequencing, may be repeated, and may be embedded one within another. (p. 121)

2.4 Formulaic Language

As I mentioned earlier, ESP specialists generally tend to focus on the relationships between form and meaning with the understanding that performing a genre requires "knowing both its schematic structure, or staging, on the one hand, and the specific form-function correlations of each state, on the other" (Flowerdew, 2011, p. 124). If writers are not familiar with the specific

patterns of specialized genres, their writing may mark them as an "outsider" of their professional contexts. Thus, ESP practitioners are often concerned with ensuring that their L2 students are equipped with the necessary language skills and proficiencies to be successful in their academic and professional matriculation. One area of research that has been explored from the ESP perspective of genre theory, is the observation of formulaic language. Where genre theorists using more ethnographic methods engage with the *recurrent* rhetorical actions of texts and discourse communities, researchers using more corpus-based approaches may observer both the recurrent rhetorical actions of texts and discourse communities in tandem with recurrent linguistic patterns (e.g., formulaic language) of discourse, both spoken and written.

Interest in formulaic language arises from research in applied linguistics having demonstrated recurrent multi-word units are frequently used in natural discourse (Biber, Conrad, & Cortes, 2003; Ellis, 1995; Ellis 2008; Gass & Mackey, 2002; Howarth; 1998; Paquot & Granger, 2012). Given the formulaic nature of language, scholars including Conklin and Schmitt (2012), Ellis, Simpson-Vlach, and Maynard (2008), and Wray (1999) have demonstrated the processing advantage that formulaic sequences have for both L1 and L2 English users for discourse purposes. Interlocuters frequently use formulaic sequences to perform recurrent communicative events (Conklin & Schmitt, 2008; Nattinger & DeCarrico, 1992). The sequences interlocuters use may also be influenced by the sociorhetorical practices of their discourse community, contributing, also, to the overall structures and uses of written texts.[2] Based on the recurrent rhetorical and linguistic patterns observed in discipline-specific genres, it is plausible that members of discourse communities also determine the linguistic features that are valuable

[2] As previously discussed in section 2.3

and necessary for new members to acquire and perform in order for communication to be considered effective.

While there is considerable scholarship on formulaic language, or formulaic sequences, it is an umbrella term that accounts for various types of multi-word units (Chen & Baker, 2010) that are typically categorized as either *recurrent* or *co-occurrent* depending on the linguistic patterns present. *Co-occurrence* refers to the statistical expectancy with which a word is to co-occur with another word, including collocations (e.g., "in other words") and idioms (e.g., "raining cats and dogs"), while *recurrence* is often defined as "the repetition of contiguous strings of words of a given length (bigrams, trigrams, etc.)" (Paquot & Granger, 2012, p. 9). For the purposes of this research, I focus on recurrent multi-word units, or n-grams. N-grams, much like lexical bundles, are generally not structurally complete and may not be idiomatic in meaning; their recurrent patterns, however, demonstrate the important functions they serve in written academic texts (see Biber, Conrad, & Cortes, 2004; Biber & Barbieri, 2007; Cheng, Greaves, & Warren, 2006). N-grams can manifest as bi-grams, tri-grams, and so forth and are similar to lexical bundles – in that they are chunks of language; however, n-grams are not impacted by the same standard of criteria as lexical bundles (e.g., frequency and range thresholds). I note these distinctions between lexical bundles and n-grams because, as I will further explain in chapter 3, my methods for extracting n-grams from the FYE corpus focused on patterns of words unique to the research context and not pre-selected lexical bundles that are common in academic discourse. Therefore, I did not apply delimiters – or punctuation boundaries – or the same frequency and range thresholds for the n-grams I analyzed. The uniqueness of the n-grams extracted from a representative corpus highlights the formulaic nature of a discourse community since the general presence of formulaic language is prevalent across

communities as interlocutors identify and recycle chunks of language used to encode a wide range of important communicative, textual, and referential functions (Gilmore & Millar, 2018). That is to say, words that are frequently used within a particular genre and academic community help shape the text and the reader's experience.

Though formulaic language is an umbrella term accounting for several perspectives and definitions, Durrant and Mathews-Aydınlı (2011) identified three main orientations to formulaic language:

1. Frequency-based approaches
2. Psychological approaches
3. Phraseological approaches

Frequency-based approaches (e.g., Chen & Baker, 2010) account for the frequency with which multi-word expressions occur (e.g., lexical bundles) and is the approach I use in this research. Frequency-based approaches allow researchers to observe how frequently (or even infrequently) a word or phrase occurs within a corpus, allowing for comparisons between dis/similar contexts and groups of writers and speakers. For frequency-based approaches to lexical bundles, the cut-off is generally conservative at 40 times per million words (see Biber, 2009) and the length of multi-word units can span from three to six, with most researchers investigating four-word units (see Biber, 2009; Biber, Conrad, & Cortes, 2004; Chen & Baker, 2010). Qualitative approaches applied to frequency-based approaches provide a more in-depth picture of how linguistic patterns function and any variations that may exist due to variables including, language background, genre, context, proficiency, register, and task (see Hunston, 2010; Staples, Egbert, Biber, & Conrad, 2015). Multi-word units, including fixed expressions and collocations, are a marker of proficient language use, particularly in academic writing contexts (Bamberg, 1983; Cortes,

2004). Learning the conventions of an academic discourse community, then, requires that learners become familiar with the expected conventions of the context, including appropriate and accurate use of expected discipline-specific multi-word units, or phrases.

Genres, a common communicative and textual function of academic disciplines, are one area in which researchers have observed the relationships between form and function, rhetorical moves, and language. For example, Henry and Roseberry (2001) identified eleven moves associated with letters of application while also mapping frequent linguistic features associated with those moves. Henry and Roseberry noted a strikingly high use of 'and' while remarking that the use of 'and' frequently occurred in binary phrases where writers were listing and describing their qualifications, a common linguistic strategy and feature within promotional genres. While students are generally exposed to chunks of language through reading, research demonstrates that this simple method of exposure to bundles through reading does not lead to their successful acquisition of bundles (Cortes, 2004; Eriksson, 2012); rather, students may benefit more from activities that foster noticing patterns of use and function between and across discourse communities (Schmidt, 1990; Neely & Cortes, 2009; Cortes, 2006; Thonney, 2011). Cortes (2004), for instance, in her descriptive study, identified targeted bundles in professional texts in History (e.g., "from the perspective of, in the name of," "the history of, on the basis of") and in Biology (e.g., "in the life cycle, in the present study," "of the variance in," "as a consequence of," "the nature of the," "for the evolution of"), and compared her structural and functional findings for these bundles to bundles observed in student writing. The variety of bundles that existed in professional texts were not represented in students' texts and the repetition of limited bundles made students' writing appear wordy and redundant. Hyland (2008) found in his descriptive research that science and engineering texts used significantly more passive bundles

and prepositional phrase fragments (as markers of logical relation) in their writing than texts representing business or applied linguistics. Hyland further noted variations in four-word bundles across four disciplines with the following six (out of 50 per discipline = 200 bundles) crossing disciplinary lines: “on the other hand,” “in the case of,” “as well as the,” “at the same time,” and “the results of the.” Hyland’s research supports previous findings (e.g. Cortes 2004) suggesting multi-word expressions vary greatly depending on discipline, context, and genre. Findings from Cortes (2004), Biber (2009), and Hyland (2008) support Gray’s (2015) argument that academic writing is not a monolithic construct; there is a range of complexity that exists within and between even similar genres (e.g., literature reviews) across academic disciplines.

2.5 Effective Communication in First Year Engineering, ESP, & Formulaic Language

Like other learning outcomes established by ABET, an ability to communicate effectively has generated a meaningful amount of scholarship as educators and researchers explore best practices for teaching discipline-specific writing strategies that meet ABET criteria (See Buswell, Jesiek, Troy, Essig, & Boyd, 2019; Ford & Riley, 2003; Ford & Teare, 2006; Koen & Kohli, 1998; Richards, Diaz, Wickliff, & Yoon, 2016; Thomas, 2005; Williams, 2001; Williams, 2002; Yalvac, Smith, Troy, & Hirsch, 2007). Faculty responsible for developing assessment plans are frequently aligning their work with ABET’s accreditation standards (see Williams 2002). The standards that ABET has established are reflected in the assessment initiatives of many engineering programs as faculty seek to establish measurable practices that provide meaningful evidence for students’ achievement of the ABET outcomes. This process of assessment, according to Williams (2002) is further meant to provide a feedback loop where assessment data is used to improve students’ education. Perhaps because of the variety of approaches used to meet ABET’s accreditation standards across engineering programs,

definitions and applications of teaching effective communication may also vary widely and depend on the needs of the context. For instance, the construct of “clear and concise” writing may not be easily generalizable between or even within engineering disciplines. One example that comes to mind is the use of passive structures and how passive structure do (or do not) interact with concepts of “clear and concise” writing, and the differences that exist between practitioner texts, academic texts (i.e., journal articles), and student texts. Conrad (2018) found some interesting differences in the uses of impersonal style features (e.g., passive structures) between civil engineering practitioners’ texts, academic journal articles, and students’ texts including: (a) practitioner reports used more active voice with inanimate subjects and human agents, (b) journal articles used more passive structures, and (c) students, although doing work that aligned more closely with the work practitioners (working with clients, specific problems, and contexts), students’ uses of impersonal style features were more aligned with the journal articles – “the student reports generally lacked human agents and even used the passive voice where inanimate subjects with active voice would have produced more concise sentences” (Conrad, 2018, p. 65). The sequencing of content is also a critical component of effective communication. Based on her research, Conrad has found that practitioner texts usually address the context and the problem before moving on to feasible solutions and their recommended solution; students’ texts, however, were often ineffective because of the sequencing of content in students’ attempts to structure an argument, leading to students alternating between the context and condition, their recommended solution, and the problem they were asked to address (Conrad, 2018, p. 66). Some of this ineffectiveness, as Conrad points out, might be explained by students having not been exposed to engineering practitioners’ writing. The sequencing of content in engineering might also be understood from a genre analysis framework, in which genre

conventions are analyzed across contexts within the same discipline (e.g., the differences between student writing, practitioner writing, and engineering faculty writing).

A central inquiry of my research is investigating how faculty perceive effective communication in FYE and how FYE's sociorhetorical values are materialized in students' writing. Buswell et al (2019), highlight six writing skills when asking engineering faculty their perceptions of undergraduate students' writing skills, including (1) appropriateness for intended audiences; (2) adherence to appropriate format for technical documents; (3) appropriate data representations (descriptive, graphical, tabular, etc.); (4) grammar, syntax, punctuation, spelling; (5) overall structure, organization flow, and logic of documents, and (6) quality and coherence of paragraph level-writing (p. 63). Appropriateness for intended audience and adherence to appropriate format for technical documents were the top skills that faculty perceived students performed well while overall structure, organization, flow, and logic of documents and quality and coherence of paragraph level-writing were the two skills that faculty perceived students performed with the least amount of acceptable skill. The skills highlighted in Buswell et al. are aligned with written technical communication taxonomy core competency skills Yalvac et al. (2007) identified as important for students to develop: (1) writing concisely; (2) using figures, tables and equations, along with text, to explain ideas; (3) synthesizing ideas from multiple research papers; (4) using headings and so forth to add structure to reports; (5) citing others' work appropriately (p. 118).

Research demonstrates that in order to support communication and writing development in undergraduate engineering, that educators and scholars are moving towards integrating interdisciplinary approaches in their curriculum design process and execution of learning outcomes (Leydens & Schneider, 2009). This move towards interdisciplinary approaches to

curriculum reflects that writing is regarded as a central practice of engineers, particularly in industry, who are required to communicate technical knowledge to a broad (often interdisciplinary) audience (Boisarsky, 2004; Wheeler & McDonald, 2000; Howard Khosronejad, & Calvo, 2016). Unfortunately, however, this move has been slow-going, particularly as it relates to addressing the international concern of the under-preparedness of university graduates in the area of effective communication within in engineering (Gassman, Maher, & Timmerman, 2013). Since engineering is recognized as a global profession, university graduates are expected to be able to communicate with team members and deliver products and documentation that are readily understood by diverse audiences (Boisarsky, 2004); often these documents are proposals, grants, executive summaries, memos, and lab reports. This expectation of being able to communicate across various audiences demonstrates what Dunsmore, Turns, and Yellin (2011) argue, that as a practice, engineering is perceived as one of "communication, teams, and multiple fields impinging on design solutions, as well as a world of engineering science fundamentals and design manufacturing practices" (p. 331). As an internationally growing field, an added complexity is the language development of recent graduates and the relationship(s) between language proficiency and fluency, and effective communication. Riemer (2007) highlights the importance of English oral communication in the engineering workplace as a daily practice. Scenarios where employees need to use English in their daily task executions are known as 'communicative events' (Kassim & Ali, 2010; Moslehifar, & Ibrahim, 2012) whereby a certain level of proficiency in English needs to be exhibited by the engineers for workplace communication efficiency (Mohamed, Radzuan, Kassim, & Ali, 2014).

Scholars in both writing studies and applied linguistics are also interested in conceptualizing effective communication. Winsor (1998), in many ways, initiated the process of

rhetoricians examining the rhetorical practices of engineers and technologists more closely, particularly when compared with the rhetorical practices of scientists and sociologists (see Bazerman, 1988; Myers; Gilbert & Mulkay, 1984). She argued that scientists and engineers use different rhetorical tools to meet their disparate goals: while science engages with explanatory theory, engineering emphasizes usefulness of objects – "the equivalent of scientific publication [for the engineer] is probably the release of the object to the marketplace. In this kind of work, the need for rhetoric is less obvious" (Winsor, 1998, p. 344). To further explicate the rhetorical practices of engineers, Winsor employed ethnographic methods including shadowing and interviews. Interestingly, Winsor makes that argument that, for engineering, technical and organizational practices are embodied rhetoric. For FYE, understanding how knowledge is formed, shared, and revised and the impacts of knowledge construction on the materialization of object-oriented tasks, is quite critical when defining and categorizing effective communication.

While ethnographic research is valuable and allows scholars to unpack the influence a rhetorical context has on shaping texts, applied linguistics has demonstrated that there are linguistic differences that allow readers and writers to identify the purposes of a text, such as autobiographies, literature reviews, memos, lab reports, technical briefs and argumentative papers (Gray, 2015, p. 1). Gray (2015) highlights that:

> A great deal of research has been devoted to describing the language of these different texts – from vocabulary use to phraseological patterns, and from grammatical characteristics to discourse structure – with the understanding that these language features are used in distinct ways in different types of academic texts. (p. 1)

In considering variables that shape perceptions of effective communication, formulaic language is a critical component of FYE students' developmental knowledge of engineering and writing in

engineering. Corpus-based approaches to research and teaching that integrate ethnographic methods as well provide insights into the discipline-specific rhetorical and writing practices. Conrad (2018) for example, used multidimensional analysis and interviews with practitioners, students, and faculty and found that engineering texts use impersonal style features more frequently than nontechnical texts. Not surprising, however, student writers tend to use significantly fewer features of impersonal style when compared to journal articles. This research is just one example from The Civil Engineering Project where mixed-methods affords greater opportunities for truly understanding discipline-specific writing that leads to effective pedagogical materials. Conrad, Pfeiffer, & Lamb (2018), note that although weak writing skills have been the topic of discussion among engineering faculty and industry stakeholders, scholars know little about the actual characteristics of engineering workplace-writing that are considered effective. For instance, they note that while "clear and concise" are general characteristics that many agree upon, these terms can vary in meaning in industry compared to academic journal venues. Importantly, they found that

> students who receive explicit instruction tying writing to civil engineering content and practice exhibit vocabulary, grammar, and organization that more effectively meet the concerns expressed by practicing engineers for accuracy, precision, liability, credibility, and client expectations. (Conrad, Pfeiffer, & Lamb, 2018)

While they do not make distinctions between L1 and L2 students, Conrad, Pfeiffer, and Lamb do point out that the pedagogical materials generated from their research are effective and useful for both L1 and L2, but especially for those students who are considered "non-traditional" students (i.e., multilingual, international, and under-represented minorities). Given the context of my research, it is important to note the benefits that this type of research and practice-based

instruction have for both L1 and L2 students given the observed rise in linguistic diversity within STEM.

The observed rise in linguistic diversity within STEM has much to do with international and domestic students being multilingual, with English often being their second, third, or even fourth language, and even domestic students being multilingual and bi-dialectal. Students using (speaking, writing, listening, and reading in) multiple languages (and dialects) in fields that are largely collaborative by nature prompts researchers to gingerly consider how the plethora of linguistic resources at play interact with the co-construction of specialized tasks within specialized disciplines. Scholars in writing studies, applied Linguistics, and engineering ubiquitously understand that writing is a social action (see Bazerman, 1988), as is the process of becoming acquainted with a new discourse community and/or discipline (Carter, Ferzli, & Wiebe, 2007). The relationship between the tasks in FYE and the process of apprenticeship is not happenstance; the writing tasks inform the community and the community informs the writing tasks in the way that Pogner (2003), in their discussion of the role of writing in engineering discourse communities, argues that "Context affects text production (writing is context-dependent), yet the inverse is also true: writing builds up and changes the context (writing is context-shaping)" (p. 856). Much of research highlights an iterative relationship between form and meaning, and my research continues this discussion by exploring how the form and meaning impact perceptions of effective communication as students engage with discipline-specific genres that have a problem statement component.

2.6 Problem Statements

While there is extensive research on various genres written in the disciplines and writing development (see Beaufort, 2008; Hyland, 2013; Soliday, 2011; Staples, Egbert, Biber, & Gray,

2016; Swales, 1990; Wilder, 2012; Winsor, 1992), scholarship on problem statements is quite limited, and there is no consensus in the literature on the functions and role of problem statements in any particular discipline, resulting in confusion regarding the common characteristics of problem statements (Hernon & Schwarts, 2007). While Hernon and Schwarts (2007) do highlight nine attributes related to problem statements, these attributes appear to be specific to research oriented publications and not specific to the field of engineering. Further, because these are publications, they are not indicative of what developing, undergraduate L1 and L2 writers produce. However, examples of these attributes include: (a) clarity and precision, (b) identification of what would be studied, while avoiding the use of value-laden words and terms, (c) identification of overarching question and key factors or variables, (d) identification of key concepts and terms, and (e) articulation of the study's boundaries and parameters (see Hernon and Metoyer-Duran, 1993). These particular characteristics are not readily applicable to the context of FYE. However, through conversations with FYE faculty and observations of their pedagogical materials problem statements written in FYE require four essential rhetorical steps[3]:

1. A clear reference to a client;
2. A clear statement regarding the need, problem, or focus of the project;
3. Clearly stated criteria; and
4. Clearly stated constraints for a possible solution.

Equally as important to the rhetorical steps and strategies that students need to make when writing problem statements, is understanding how problem statements fit within larger genres such as design reports. Understanding that problem statements do not occur in isolation, we might consider viewing problem statements as scaffolded, task-based writing. Faculty in FYE

[3] There is more explanation on these rhetorical steps and genre conventions in chapters 4 and 5.

often articulate the need for students' to be aware of the rhetorical situation and their potential audiences, expressing a need for students to develop clarity and conciseness in writing. Problem-statements are, thus, engineered toward scaffolding students in the writing process to develop the necessary skills for discipline-specific writing as well as knowledge of the discourse community. In this sense, problem statements act as a peripheral task, or an apprenticeship genre (see Lave & Wenger, 1991). In their research looking at the connections between writing to learn and learning to write in the disciplines and the role of writing in students' enculturation process to specific disciplines, Carter, Ferzli, and Wiebe (2007) explain that "Apprenticeship is typically defined by tasks that are simpler than those of full participants, tasks that do not carry the responsibility that full participation bears" (p. 284). They further argue that apprenticeship genres are critical in the socialization process of undergraduate students into disciplinary communities. Apprenticeship genres that they identify are lab reports, literary critiques, market analyses, and social science research reports. These genres speak to the characteristics of *doing* in various disciplines. These ways of *doing* encourage specific ways of *knowing* in disciplinary communities. Problem statements are a way of *doing* in FYE that facilitates ways of *knowing*.

Swales (1990) classified introductions (of research articles) as problem-solution texts, wherein Zappen (1983) argues that researchers are required to address "the goals, current capacities, problems, and criteria of evaluation that derive from and operate within that discipline" (p. 130). Swales found in his examination of engineering research article introductions that the texts were rich with evaluative commentary in which writers address the expectations of the discourse community, the advances in research, and their own contributions. While Swales' work does not investigate problem statements specifically, his move-step analysis

of introductions, particularly those classified as “problem-solution” texts, provides rich insight into the expectations of engineering writing that is applicable to this study.

2.7 Chapter Conclusion

My research extends the work of Conrad, Winsor, Tardy, and Swales, and invites a conversation between WID/WAC specialists and ESP specialists by engaging in an iterative quantitative-qualitative mixed-methods approach drawing on two traditions of genre theory: New Rhetoric and ESP. In the following chapter, I provide the details for my research design and methods.

CHAPTER 3. RESEARCH DESIGN AND METHODS

3.1 Introduction

In this chapter I outline the methodology, methods, and research design for answering the research questions for this dissertation. I provide an overview of the research context, research variables, description of the data and corpus, and data analysis procedures.

The methodology for this dissertation reflects that writing does not exist in a vacuum; linguistic and stylistic variation between groups of (and individual) writers often depends on their purposes, their audiences, their knowledges, and their language and communicative proficiencies. FYE students' purposes, audiences, knowledges, and proficiencies are determined, and, at the very least influenced by, FYE faculty's pedagogical decisions and definition of *effective communication*. My methodological choices are also reflective of my theoretical and conceptual frameworks, specifically the application of genre analysis from the ESP perspective to understanding *how* and *why* students write problem statements in FYE. ESP provides "authentic descriptions of specialized language-in-context for teaching purposes" by adopting both qualitative and quantitative methods of inquiry (Dressen-Hammouda, p. 502, 2012). Table 3.1 provides a detailed description of the data and methods used to answer each of the research questions.

Table 3.1 Description of Data and Methods

Research Question	Data	Method
RQ1: Based on faculty perceptions, what constitutes 'Effective Communication' in FYE?	Individual interviews with FYE Faculty (n=3) using texts from the corpus and pedagogical materials	Discourse-based interviews. Codes were qualitatively identified using NVivo.
RQ2: What are the expected rhetorical moves and steps of problem statements?	Pedagogical materials from ENGR 131 for all three assignments and corpus of students' texts from ENGR 131	Quantitative-qualitative analysis of corpus. Qualitative analysis of pedagogical materials. Interview data to triangulate findings.
RQ3: What formulaic language represent the rhetorical moves and steps of problem statements, as indicated in the pedagogical materials and students' texts?	Pedagogical materials from ENGR 131 for all three assignments and corpus of students' texts from ENGR 131	Quantitative-qualitative analysis of corpus. Qualitative analysis of pedagogical materials. Interview data to triangulate findings.
RQ4: Do students use the formulaic language from pedagogical materials across all three assignments?	Pedagogical materials from ENGR 131 for all three assignments and corpus of students' texts from ENGR 131	Quantitative-qualitative analysis of corpus. Qualitative analysis of pedagogical materials.

To answer the research questions, I used an iterative quantitative-qualitative approach to written discourse analysis including the application of corpus-based methods, discourse-based interviews, and qualitative textual analysis. This mixed-methods approach allowed me to analyze both the recurrent patterns of language across typified genres and how faculty perceived effective communication based on students' writing. Using a frequency-based approach (see Chen & Back 2010; Biber et al, 2009), I quantitatively identified the most frequent four-word and six-word sequences in the FYE corpus using AntConc (Anthony, 2018) for three

assignments: (1) the airplane rodeo assignment, (2) the net zero energy assignment, and (3) the final design project. I then manually identified and removed any overlap that existed in the most frequent n-grams for each assignment – the first assignment consisted of the top 50 n-grams, while the last two assignments consisted of the top 20 n-grams; I then qualitatively coded 15% of each n-gram for each assignment for their rhetorical functions (i.e., move/step analysis). My framework for the move/step analysis is an adaptation of Swales' (1990) work. Iteratively, I qualitatively analyzed the pedagogical materials to identify the expected generic moves and steps of problem statements, mapping the formulaic language that was present in both the corpus and the pedagogical materials in order to observe how students did (or did not) adapt the instructional materials for their own writing. Lastly, I quantitively observed the frequencies with which each move and step occurred across all three assignments, noting any relevant and noteworthy findings. To triangulate my findings, I conducted discourse-based interviews with three FYE faculty. Interview data was recorded, transcribed, and then qualitatively analyzed and coded using NVivo – such triangulation provides a wider, more accurate description of writing in First Year Engineering.

3.1.1 Data Collection and Analysis: An Iterative Process

As I mentioned in the previous section, the data collection process occurred in two stages: the collection of students' texts, pedagogical materials, and the existing FYE survey data were part of stage 1 while the discourse-based interviews were part of stage 2. The data analysis process, while there are two distinct beginning stages, was iterative. Figure 3.1 shows both the stages for the data collection and the data analysis process. During stage 1 of the data analysis process, I conducted a corpus analysis of students' texts, focusing on 4- and 6-word sequences across all three assignments; iteratively, I analyzed the pedagogical materials observing the relationship

between students' texts and the language in the pedagogical materials. This process led to the identification of formulaic language in the corpus. The analysis of the pedagogical materials and students' texts further led to the identification of the moves and steps identified in students' writing. Stage 2 of data collection and data analysis began just after the identification of formulaic language and moves and steps in students' texts. Interview data was not only exploratory in nature in order to further understand how faculty perceive effective communication and interact with students' texts but also used to confirm the moves and steps identified in students' texts and the pedagogical materials; thus, the process of analyzing the interview data was also iterative in that I continued my analyses of the pedagogical materials and the corpus. Finally, formulaic language in students' texts were then coded for the rhetorical functions (e.g., moves and steps) they performed, and interview data was coded for themes of effective communication.

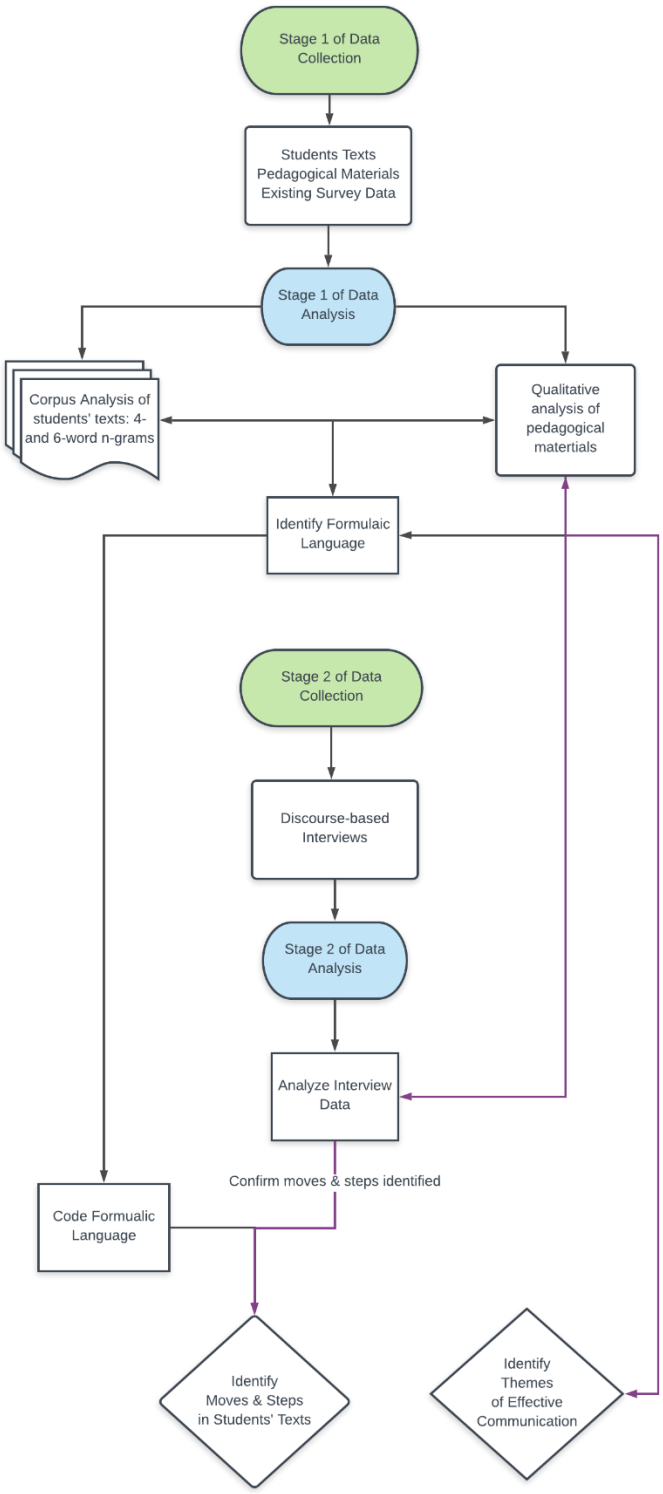


Figure 3.1 Research Design and Data Collection Process

3.2 Research Context

This research takes place at a STEM-focused research institution in the Mid-west, Purdue University, within the First Year Engineering program (FYE). Important to this research is understanding that Purdue is one of very few U.S. universities with an engineering education program and an FYE program in the U.S. Additionally, Purdue was ranked third for international student enrollment at U.S. universities at the time of the research. In fall of 2017, 31,006 freshmen enrolled at Purdue. Of those new freshmen, 23%, or 8,918, of those students enrolled into the College of Engineering. Of the 8,918 new freshmen in engineering, 4,964 of those students were international. Part of the FYE curriculum includes building multicultural awareness by placing students in groups of four based on their schedule, sex, language background, and race. A key component of the FYE curriculum that this dissertation emphasizes is FYE students are strategically placed so that no one student from a diverse background is "alone." In this context, all the writing done collaboratively, save for a few individual assignments that are used for scaffolding purposes. Individual assignments are not included in this data set.

3.2.1 ENGR 131

Every semester, over 1500 students enroll in ENGR 131 – an introductory course to engineering design. The focus of the course is to build students' content knowledge of engineering through multidisciplinary approaches and collaborative and cooperative learning efforts. According the course syllabus, ENGR 131 is focuses on developing students' skills in project management, engineering fundamentals, oral and graphic communication, logical thinking, and the use of modern engineering tools. Based on the Accrediting Board of Engineering and Technology

(ABET) outcomes, ENGR 131 has 9 course objectives for students to achieve (those objectives in bold are of particular importance to ENGR 131 as indicated on their syllabus):

1) an ability to apply knowledge of mathematics, science and engineering
2) **an ability to design and conduct experiments, as well as to analyze and interpret data**
3) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
4) **an ability to function on multidisciplinary teams**
5) an ability to identify, formulate, and solve engineering problems
6) an understanding of professional and ethical responsibility
7) **an ability to communicate effectively**
8) a recognition of the need for, and an ability to engage in life-long learning
9) **an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.**

The curriculum for ENGR 131 is developed by a team of experts and implemented by professors and instructors of engineering. Of particular importance and interest to professors and curriculum developers for ENGR 131 is teaching students effective communication in writing. After a series of consultations, it was expressed that students in ENGR 131 have difficulty with the following in their writing: (1) a variety of grammatical errors, (2) issues with coherence and conciseness, (3) issues with clarity, and (4) issues with imprecise word choice.

3.2.2 FYE Student Demographics for Fall 2017

In Fall of 2017, 1,736 students were enrolled in the FYE program at Purdue University. Of those 1,736 students, 239, or 8%, of them identified as international on the survey administered by FYE faculty. Additionally, and also surprisingly, only 60 students of the 1,736 enrolled in FYE identified a language other than English as their L1. Interestingly, students who identified as international often identified with English as their L1, while several students who identified as domestic identified with English as their L2. Other demographic information of the FYE student population included here, as demonstrated in Tables 3.3 and 3.4, are students' self-reported race and gender. 1244 students identified as male, 423 students identified as female, 7 students identified as "other" and 60 students did not report their gender. Additionally, 1096 students identified as White, 299 students identified as Asian, 169 students identified as Hispanic, 33 students identified as Black, 2 students identified as Native American, 50 students identified as "other," 31 students declined to respond, and 56 students did not report their racial identity.

I would like to point out that the information gathered here may not be reflective of students' actual identity, especially regarding to students' self-reported L1 background and international status.

Table 3.2 Self-reported Status

Self-reported Status of FYE Students	Number of Students
Domestic Students	1,497 (92%)
International Students	239 (8%)
Total Fall 2017 FYE Student Population	1,736

Table 3.3 Self-reported Sex

Self-reported Sex of FYE Students	**Number of Students**
Male	1244 (72%)
Female	425 (24%)
Other	7 (1%)
No Response	60 93%)

Table 3.4 Self-reported Race

Self-reported Race of FYE Students	**Number of Students**
White	1096 (63%)
Asian	299 (17%)
Hispanic	169 (10%)
Black	33 (2%)
Native American	2 (.11%)
Other	50 (3%)
Declined to respond	31 (2%)
No Response	56 (3%)

Table 3.5 Self-reported Language Background

Self-reported Language Background of FYE Students	**Number of Students**
English (L1)	1,676 (96%)
Second Language (L2)	60 (4%)

3.3 Overview of Data and Corpus

Texts for the corpus and the pedagogical materials for this dissertation were collected in March of 2018 after IRB approval. All textual data is from the Fall 2017 semester; collecting Fall 2017 data in spring 2018 reduced risk to students as their final grades were already submitted. Section 3.2.2 provides a description of the corpus; briefly, however, the corpus includes three writing assignments with a problem statement component: (1) The Airplane Rodeo assignment, a technical brief, (2) The Energy assignment, a technical report, and (3) their Final Projects, a technical report. While the first two assignments were fairly consistent in format and genres, there was considerable variation in the last assignment where some of the instructors for the 15 sections opted to have students write reflections on the design process rather than more conventional technical reports. Additional data for this dissertation includes the survey responses FYE collects every semester on students' demographic background, including race, sex, international/domestic status, and language background, as reported in Tables 3.2, 3.3, 3.4, and 3.5. Lastly, discourse-based interviews with FYE faculty were also collected during the fall semester of 2018. Table 3.6 provides a count of each of these data sources.

Table 3.6 Data Sources Collected

Pedagogical Materials Collected	Co-Authored Student Texts Collected	Discourse-Based Interviews	Existing Survey Data
117	1,320	3	1,676 Respondents

3.3.1 Description of Data Sources and Data Collection Procedures

FYE Student Texts from fall 2017 semester were collected via Blackboard by FYE's Instructional Support Manager and uploaded to a secure drive. In addition to collecting students'

texts for this project, the instructional support manager uploaded the pedagogical materials ENGR 131 professors use to teach these assignments. Upon collection, texts were (1) converted to txt files and formatted to UTF-8, (2) cleaned, (3) de-identified, and (4) labeled according to group demographics with an emphasis on students' language background (L1 or L2) and their international/domestic status. Meta data from the existing survey provided by FYE was included in each text. Because the focus of this research is on problem statements, students' texts were compiled into a small, localized corpus and then a sub-corpus was created that contains only the problem statements and the immediately surrounding text from each assignment. This allowed me to focus on the problem statements for my analyses, while still maintaining access to the larger genres that problem statements live in. Specifics about the corpus compiling process are in sections 3.3.2 and 3.3.3 of this chapter.

Existing Survey Data was also collected from FYE. FYE uses a survey to collect self-identified demographic information from ENGR 131 students every semester; Tables 3.2, 3.3, 3.4, and 3.5 provide descriptions of students' self-identified information. FYE professors use this information to place students in groups for the duration of the semester. Each group is intended to be racially, ethnically, and linguistically diverse. FYE's Instructional Support Manager collected the survey results, an excel sheet, and included this in her data collection process for each section of ENGR 131. Survey data was used to create file names indicating whether a text was written by a group that is English mon-lingual (L1) or multi-lingual (L2) and also provide demographic information of the writers, such as their sex, race, and whether they are international students or domestic students. Table 3.7 provides information on the how many students, groups, assignments, and number of international students per section.

Table 3.7 Number of Students, Groups, Assignments, and International Students per Section

Section	Number of Students	Number of Groups	Number of Assignments	Number of International Students
001	120	30	3	16
004	119	30	3	19
005	120	30	3	12
007	114	28	3	22
011	116	30	3	11
012	118	30	3	10
013	118	30	3	19
014	117	30	3	12
015	117	30	3	13
016	119	30	3	11
017	115	29	3	9
018	118	30	3	11
019	101	29	3	24
010	106	27	3	30
024	118	30	3	20

3.3.2 Description of Corpus

This localized corpus consists of 1,192 texts collected from FYE. As mentioned earlier in this chapter, texts were collaboratively written by students in groups of three to four. The FYE corpus has three different assignments, all of which have a problem statement component: 433 texts from the first assignment, the Airplane Rodeo Technical Brief; 434 texts from the second assignment, The Energy Assignment, a technical report; and 325 texts from the final projects, a design report. All assignments were students' final submissions for a grade – no drafts were collected; however, grades and comments from instructors were not collected. Additionally, all texts collected were collaboratively written.

Once the main FYE corpus was compiled, a sub-corpus was compiled consisting of only the problem statements and immediately surrounding text from each of the three assignments. The sub-corpus was compiled manually so to ensure that the problem statements for each assignment were accurately captured. Dividing the corpus this way allowed me to analyze problem statements in isolation and also analyze them while embedded in larger genres. For the first assignment, the cut-off point for the problem statement was measured by the pedagogical materials and the description of the sections that students were asked to write for their technical memo; based on this information, I decided to analyze the first section of the first assignment, the introduction. For the second and third assignments, it was more advantageous to analyze the problem statement within the executive summary, the introduction to the students' larger texts, which often exceeded 10 pages, because, as the data analysis and results will demonstrate, problem statements were not consistently in one location (i.e., the beginning). As Table 3.9 shows, total number of texts for the final project were comparatively fewer; this was a result of having to identify which texts for the final assignment were reflections and which texts were design reports; those texts that were identified as final reflections were excluded from the sub-corpus because they did not include problem statements.

Table 3.8 below provides detailed information of the corpus compiled for this dissertation, including total number of files per assignment, total number of word types per file, total number of word tokens per file, and total number of word types and total number of word tokens. Table 3.9 provides detailed information of the sub-corpus for problem statements, including total number of files per assignment, total number of word types per file, and total number of word tokens per file.

Table 3.8 Description of Corpus

Assignment	Total Number of Texts	Total Number of Word Types	Total Number of Word Tokens
Airplane Tech Brief	433	6,900	381,508
Energy Tech Brief	434	12,199	958,701
Final Project	325	18,273	913,499
Overall Total	1,192	37,372	2,253,708

Table 3.9 Description of Sub-corpus

Assignment	Total Number of Texts	Total Number of Word Types	Total Number of Word Tokens
Airplane Tech Brief	427	3,019	101,069
Energy Tech Brief	433	5,993	296,776
Final Project	259	6,516	133,573
Overall Total	1,119	15,528	531,418

Building the corpus included the following steps:

1. converting files from Word.docx to txt.files;
2. processing and cleaning files;
3. adding meta-data: race, sex, international/domestic and language background of groups
4. naming files based on course section, group number, language makeup of group (“mono” for monolingual, “multi” for multilingual, “inter” for international, and “dom” for domestic), and whether or not students are domestic or international, assignment, draft: 001_02_mono_dom; and
5. de-identifying texts: removing all names from files once meta-data was included.

The following section provides details on cleaning and processing the files for the FYE corpus.

3.3.3 Data Cleaning and Processing

Once the data was collected and organized, the majority of the processes were automated using a variety of python scripts. The first step in getting the data ready for analysis was converting all files from Word and PDF into txt. files. To do this, I used a program called Zilla Word to Text. Once the files were converted, and with the help of a colleague and programming consultant, several Python scripts were generated to (1) clean the txt files (normalizing punctuation), (2) provide header (or meta data) information to each file retrieved from a CSV file of all student demographic information, (3), properly label the file names based on student demographics and assignment name, and (4) de-identity the files. Processing the files in this manner made them compatible with AntConc, the corpus analysis tool I used in to quantitatively analyze texts. Below is an example of header (meta data) information added to each file:

<Group: 001_01>
<Assignment: Airplane Tech Brief>
<Draft: 1>
<Term: Fall 2017>
<Program: FYE>
<Author1Language: English>
<Author1Gender: Male>
<Author1Race: Asian
<Author1Status: International>
<Author2Language: English>
<Author2Gender: Male>
<Author2Race:Asian>
<Author2Status: International>

<Author3Language:English>

<Author3Gender:Male>

<Author3Race: White

<Author3Status: Domestic>

<Author4Language: Related>

<Author4Gender: Male>

<Author4Race:Hispanic>

<Author4Status:International>

3.4 Research Variables

To answer the research questions specific to the genre conventions of texts with problem statements and the formulaic language students use (or fail to use), I divided the research variables into two primary categories: linguistic variables of interest and non-linguistic variables of interest. Table 3.10 provides a list of these variables; these include: four-word clusters, six-word clusters, appropriateness of word choice, total words produced, and students' language background, race, sex, and international/domestic status. The linguistic variables were analyzed using AntConc and through qualitative coding of n-grams identified in the corpus. Clarification on the effectiveness of students' texts were investigated with discourse-based interviews.

Table 3.10 Research Variables

Linguistic Variables	**Non-linguistic Variables**
Four-word clusters	Assignment Type
Six-word clusters	
Appropriateness of Word Choice	
Total Words Produced	

Broadly, of primary interest to this dissertation research is students' use of the formulaic language (four- to six-word clusters) as quantitatively identified using AntConc and how formulaic language perform the rhetorical moves and steps expected in problem statements. Because the frequencies for four- and six-word clusters were quite high (often above 300), a minimum frequency did not need to be established. Rather, I generated a cut-off point for data management purposes where I analyzed the most frequent occurrences in the data set, coding only 15% of each n-gram for rhetorical function. Additionally, I did not limit to clusters that only occurred in all three assignments as many of the clusters, as will be discussed in chapter 5, were content words based on the problem(s) students were asked to solve. I did note which formulaic language occurred across all three assignments, particularly if students maintained formulaic language from the first assignment across all three assignments, coding their rhetorical functions they performed. While four-word sequences are found to be the most common word length for formulaic language research, I was less conservative with the range of n-grams so that I may account for how students may deviate from the formulaic language prescribed; limiting to 4-word or even 5-word clusters would have prevented me from observing any variations in formulaic language that existed. Additionally, for the first assignment, the Rodeo Tech Brief, I opted to analyzed 6-word clusters to aid in eliminating overlap. For the second assignment, Energy Tech Report, and the third assignment, Final Project, I opted to analyze 4-word clusters. For each assignment, I manually removed any overlap that existed between n-grams. As formulaic language was analyzed, the ways in which students either maintained (or deviated from) the "formulas" provided to them in the pedagogical materials throughout all three assignments were coded (move-step analysis).

3.5 Data Analysis Procedures

This section describes the data analysis procedures for the move-step analysis of problem statements and discourse-based interviews.

3.5.1 Development of moves and steps

The definition and categorization of problem statements and the various moves and steps that are described in chapter 5 drew on established, cross-disciplinary move-step analysis frameworks for various genres and sub-genres, including personal statements (Ding 2007), results sections for research-reporting articles (Bruce, 2009), methods sections (Cotos, Huffman, & Link, 2017), research articles in engineering (Maswana, Kanamaru, & Tajino, 2015), application letters (Henry & Roseberry, 2001; Upton & Connor, 2001), and discussion sections across several disciplines (Holmes, 1997). The analysis of genres and their rhetorical moves was originally established by Swales (1981) to describe and categorize the recurrent organizational patterns of research articles; as such, the scholarship above all use Swales' framework as grounding for their research – as do I.

Moves, according to Swales, are sections of a text that perform particular communicative functions. The combination of these moves defines the constraints of a genre and "shapes the schematic structure of the discourse and influences and constrains choices of content and style… [with] various patterns of similarity in terms of structure, style, content, and intended audience" (Swales, 1990, p. 58). My analysis procedures for identifying moves took part in three phases. The first phase was an exploratory analysis of students' texts alongside pedagogical materials to identify recurrent patterns that existed between the two text types and possible functions for problem statements. I identified potential recurrent patterns using an iterative qualitative-quantitative approach wherein I identified the most frequent four-word and six-word clusters in

the sub-corpus, observing the possible relationships between the n-grams, students' texts, and the pedagogical materials. I then tentatively identified moves and steps applicable to problem statements. The second phase included the development of a coding rubric for n-grams identified in the corpus for all three assignments and input from interviewees via discourse-based interviews wherein participants either confirmed or corrected my findings. The rubric was refined by the data collected during the interviews and inter-coder reliability where feedback and discussions on the moves and steps I identified occurred. In the third phase, I coded 15% of the top 50 n-grams for the first assignment, the top 10 n-grams for the second assignment, and the top 15 n-grams for the third assignment identified in the corpus, mapping them to their respective rhetorical move and step. The number of n-grams identified and coded for each assignment was determined by the frequencies within which they occurred and any possible overlap. Once overlap was manually identified and removed, 10 n-grams were coded for the first assignment, 7 n-grams were coded for the second assignment, and 9 n-grams were coded for the third assignment. Altogether, two moves and 13 steps were identified.

The coding scheme I used for the move/step analysis generated the rhetorical function codes framework I used to analyze each of the 4-word and 6-word n-gram. Table 3.11 provides the rhetorical function codes used to map the n-grams for each assignment. Appendix A provides the complete coding rubric with examples for each of the codes in Table 3.12.

Table 3.11 Move-Step Codes

Code	Description
CR	Client Reference
CN	Client Needs
JP	Justification of Problem
PCN	Purpose of Client's Need(s)
IC	Identification of Criteria
IC2	Identification of Constraints
IL	Identification of Limitations
ITO	Identification of Trade-offs
IA	Identification of Assumptions
DSFD	Description of Final Design/Solution
REFL	Reflection of Decisions Made
IUT	Inaccurate Use of Term
NA	Incomplete (students did not complete the task)

3.5.2 Inter-coder Reliability

After I coded all n-grams, 10% of each coded n-gram was randomly selected and coded by a second coder to check for inter-coder reliability. The second coder is a graduate student in the Second Language Studies program at Purdue University and is familiar with the process of coding textual data. To prepare for the process, the second coder and I met to discuss the coding rubric and to go over engineering-specific terminology. We then had a training session where we practiced coding a few of the n-grams (not selected for her coding process) and went over any discrepancies. After our meeting, the coding assistant coded all of the data (73 total codes). While she was advised to contact me with any questions or a request for more context surrounding the extracted concordance lines, she opted to code the data in one batch. To check inter-coder reliability, I manually compared the coding assistant's codes to mine and calculated

instances that were in disagreement. Out of the 73 total codes, only 12.33% were in disagreement with 87.67% in agreement.

3.5.3 Discourse-based Interviews

Discourse-based Interviews were conducted with three faculty and staff in the School of Engineering Education: Dr. Amanda Robins, Dr. Amelia Rodriguez, and Dr. Ada Reis. Each of the faculty were given pseudonyms in order to maintain their confidentiality. Interviewees were selected based on recommendation from the Assistant Head of FYE. Upon approval from IRB, emails were sent to all three potential interviewees, formally inviting them to participate in this research. Participants signed a consent form prior to being interviewed. Each of the faculty have unique perspectives on the role of writing in FYE based on their prior industry experience, education level, experience teaching within the FYE context, and their language background. The table below provides a profile for each interviewee, including their gender, industry experience, years teaching at Purdue, country of origin, and their language background.

Table 3.12 Interview Participants

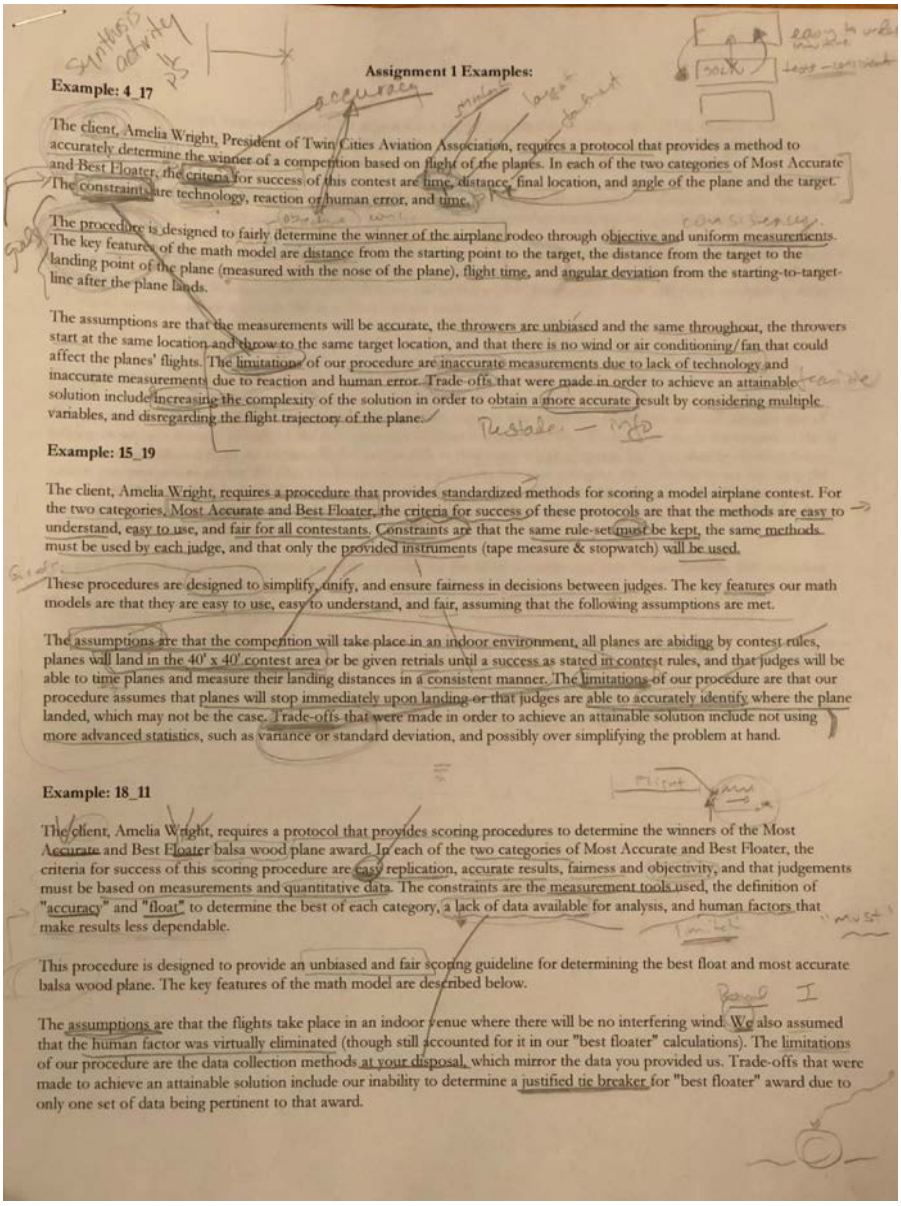
	Gender	**School**	**Industry Experience**	**Years Teaching at Purdue**	**Country of Origin**	**First Language**
Dr. Amelia Rodriguez	Female	School of Engineering Education	Yes	5	Columbia	Spanish
Dr. Ada Reis	Female	School of Engineering Education	No	9	Turkey	Turkish
Dr. Amanda Robins	Female	School of Engineering Education	Yes	13	U. S	English

Dr. Amelia Rodriguez was the first interview participant for this research, lasting 60 minutes. Our interview took place on October 1, 2018 at 3:00pm in her office. We chose her office because we were able to control the noise levels and because she had another appointment immediately after ours. Dr. Rodriguez joined the Purdue School of Engineering faculty in 2014 as a post-doctoral research assistant in FYE; her research focuses on how to better teach and learn engineering practices in a multicultural world. During our interview, Dr. Rodriguez answered 10 questions related to problem statements and effective communication in FYE (see Appendix B). Included in these questions were prompts to identify texts from the textual case studies that demonstrate in/effective writing strategies with explanations for her decisions. Her interview was recorded for memory purposes and then stored on a secure drive where I later transcribed my interview with her for coding purposes. Interview coding will be described later.

Dr. Ada Reis was the second interview participant for this research lasting 90 minutes on November 5, 2018 from 2:30pm to 4:00pm at a local coffee shop. A local coffee shop was selected based on Dr. Reis' preference. Dr. Reis was asked 13 questions related to problem statements and effective communication (see Appendix C); her questions varied from the previous interview with Dr. Rodriguez in order to gain a better understanding of the role of writing in FYE. Additionally, the questions for Dr. Reis were revised to more accurately reflect the students' texts in order to gather explicit examples of in/effective communication strategies used by students.

Dr. Amanda Robins was the third interview participant for this research lasting just under three hours on December 11, 2018 from 2:30-5:30 in her office on campus. We chose her office based on convenience and for noise control. Dr. Robins' interview was unexpectedly longer than the previous interviews and only 120 minutes were recorded. Additional interview

data was jotted down by hand in a more casual conversation style. Dr. Robins' was asked 21 questions related to her background in industry and teaching, effective communication in FYE, and problem statements (see Appendix D). Dr. Robins' interview was the most comprehensive in part because of her extensive background in teaching and industry, but also because of her own research interests in cross-disciplinary communities. Additionally, I used texts from the corpus rather than the textual case studies with Dr. Robins' interview in order to further triangulate findings from my corpus analysis. Figure 3.2 provides an example of how interviewees engaged with the texts during their interviews.



Assignment 1 Examples:

Example: 4_17

The client, Amelia Wright, President of Twin Cities Aviation Association, requires a protocol that provides a method to accurately determine the winner of a competition based on flight of the planes. In each of the two categories of Most Accurate and Best Floater, the criteria for success of this contest are time, distance, final location, and angle of the plane and the target. The constraints are technology, reaction or human error, and time.

The procedure is designed to fairly determine the winner of the airplane rodeo through objective and uniform measurements. The key features of the math model are distance from the starting point to the target, the distance from the target to the landing point of the plane (measured with the nose of the plane), flight time, and angular deviation from the starting-to-target-line after the plane lands.

The assumptions are that the measurements will be accurate, the throwers are unbiased and the same throughout, the throwers start at the same location and throw to the same target location, and that there is no wind or air conditioning/fan that could affect the planes' flights. The limitations of our procedure are inaccurate measurements due to lack of technology and inaccurate measurements due to reaction and human error. Trade-offs that were made in order to achieve an attainable solution include increasing the complexity of the solution in order to obtain a more accurate result by considering multiple variables, and disregarding the flight trajectory of the plane.

Example: 15_19

The client, Amelia Wright, requires a procedure that provides standardized methods for scoring a model airplane contest. For the two categories, Most Accurate and Best Floater, the criteria for success of these protocols are that the methods are easy to understand, easy to use, and fair for all contestants. Constraints are that the same rule-set must be kept, the same methods must be used by each judge, and that only the provided instruments (tape measure & stopwatch) will be used.

These procedures are designed to simplify, unify, and ensure fairness in decisions between judges. The key features our math models are that they are easy to use, easy to understand, and fair, assuming that the following assumptions are met.

The assumptions are that the competition will take place in an indoor environment, all planes are abiding by contest rules, planes will land in the 40' x 40' contest area or be given retrials until a success as stated in contest rules, and that judges will be able to time planes and measure their landing distances in a consistent manner. The limitations of our procedure are that our procedure assumes that planes will stop immediately upon landing or that judges are able to accurately identify where the plane landed, which may not be the case. Trade-offs that were made in order to achieve an attainable solution include not using more advanced statistics, such as variance or standard deviation, and possibly over simplifying the problem at hand.

Example: 18_11

The client, Amelia Wright, requires a protocol that provides scoring procedures to determine the winners of the Most Accurate and Best Floater balsa wood plane award. In each of the two categories of Most Accurate and Best Floater, the criteria for success of this scoring procedure are easy replication, accurate results, fairness and objectivity, and that judgements must be based on measurements and quantitative data. The constraints are the measurement tools used, the definition of "accuracy" and "float" to determine the best of each category, a lack of data available for analysis, and human factors that make results less dependable.

This procedure is designed to provide an unbiased and fair scoring guideline for determining the best float and most accurate balsa wood plane. The key features of the math model are described below.

The assumptions are that the flights take place in an indoor venue where there will be no interfering wind. We also assumed that the human factor was virtually eliminated (though still accounted for it in our "best floater" calculations). The limitations of our procedure are the data collection methods at your disposal, which mirror the data you provided us. Trade-offs that were made to achieve an attainable solution include our inability to determine a justified tie breaker for "best floater" award due to only one set of data being pertinent to that award.

Figure 3.2 Example from Discourse-based Interview with Dr. Robins

3.5.4 NVivo: Coding Interview Data

In order to code the interview data, I used NVivo 12 to create unique cases for each interview participant and unique codes for themes that emerged during the interview. For the purposes of my research, I used an inductive analysis approach (see Thomas, 2006) where concepts of effective communication were derived from the raw interview data. For example, for *effective communication* themes emerged that were related to language and vocabulary, audience awareness, measurability and data, organization, clarity and conciseness, and the influence of pedagogical materials. The themes identified and coded for in the analysis created the framework from which I worked. Because each participant had example texts to work from, I then mapped the codes from the interviews with the texts in order to provide student examples for each code, when applicable. Findings from the coding were then applied to the corpus analysis for the qualitative coding of each rhetorical step so that I might quantify instances of ineffective and effective communication. The Table 3.13 provides coding framework with the nodes from NVivo that were used to code the interview data.

Table 3.13 Effective Communication Codes

Effective Communication Codes
Audience Awareness
Organization, Structure, & Logical Flow
Genre Conventions & Formality
Specificity of Content & Data
Vocabulary & Discipline-specific Meanings
Clarity & Conciseness
Mechanics, Grammar, Punctuation, & Syntax
Reflective Writing
Impact of Pedagogical Materials

3.6 Chapter Summary

This chapter provided information on the research design and methods used to answer the research questions for this dissertation. The data analysis and results for how faculty perceive effective communication follows in chapter 4.

CHAPTER 4. FIRST YEAR ENGINEERING PEDAGOGY AND EFFECTIVE COMMUNICATION

4.1 Introduction

This chapter addresses the first research question for this dissertation:

1. Based on faculty perceptions, what constitutes 'Effective Communication' in First Year Engineering?

I begin this chapter by revisiting *genre* and the relationship(s) between recurrent rhetorical patterns and perceptions of effective communication. What is of particular importance in this chapter are how pedagogical materials influence students' texts and the disparities that arise between faculty and pedagogical materials as interviewees begin to unpack their expectations for students' writing and how they define *effective communication*. To demonstrate the fluidity and often conflicting perceptions of effective communication and the degree to which pedagogical materials influence students' writing, I have displayed the data in such a way where the reader can see (1) the interview data, (2) the texts used during the interview data, and (3) the pedagogical materials associated with the texts for each example. Finally, this chapter discusses the potential benefits of applying an ESP framework and corpus-based approach to teaching discipline-specific writing for the purposes of bolstering strategies and skills that faculty have identified as critical for effective communication in First Year Engineering.

4.2 Faculty Perceptions of Effective Communication

Research question one asks how faculty define, understand, and teach effective communication in First Year Engineering (FYE). Conceptualizing what constitutes effective communication in FYE requires a clear and firm understanding of the genres taught in this context and the expectation and purposes of those genres as identified through qualitative analyses of

pedagogical materials, students' texts, and discourse-based interviews. As I previously discussed in chapter 2, genres are products of the purposes of communities of practice as manifested in the recurrent texts that discourse communities employ (see Johns, 2002; Miller, 1994; Swales, 1990); thus the complexity of the relationship(s) between writers, readers, texts, and social conditions and expectations makes it implausible to "determine what is an 'appropriate' or 'effective' text in any discourse community or discipline without first considering the social and intellectual activity which the text is part of" (Bazerman, 1988, p. 4). The purpose and the structure of a genre are further indicative of a community's purpose and focus. In addition to the rhetorical orientation of genres and recurrent rhetorical patterns of texts, recurrent linguistic patterns also provide insights into the expectations of discourse community has in terms of the role language plays in performing certain rhetorical functions.

As the data will show, for FYE, genres are pedagogical tools used to familiarize students to a new culture of thinking, doing, and engaging. The purpose of any genre written in this context is to provide students with the opportunity to internalize and recycle new knowledge (procedural and content) via chunks of language provided to them through instruction and various pedagogical materials. Interview data and analyses of the pedagogical materials provide a snapshot of the role of problem statements and the expected written conventions, including the rhetorical moves and steps. One observation, that I should note now, is that problem statements are not genres in and of themselves; a problem statement in FYE is a rhetorical move that generally occurs at the beginning of text (e.g., a technical memo) and is comprised of a group of rhetorical steps, or strategies, used to make this move. Variation in when and how these steps are performed exist and are further explained and outlined in chapter 5. Knowing where a problem statement occurs and its rhetorical function within a larger genre further clarifies faculty

perceptions of effective communication as it relates to the strategies students use when writing problem statements.

4.2.1 Problem Space vs Solution Space: Defining Problems and Solutions

Throughout chapter 4 and chapter 5, I often use the terms *problem space* and *solution space*. The terms *problem space* and *solution space* as borders for the two distinct moves observed here in chapter 4 and later in chapter 5 come directly from the interview data where participants refer to the component of text as a *space.* When I refer to a *space*, I am referring to a specific area of a genre type that contains a rhetorical move: either students are working with a problem in the *problem space*, which should include a problem statement, or they are working with a solution in the *solution space*, which may also reflect overlap with the problem state. The rhetorical steps of which these moves are comprised determines whether students have appropriately identified the space within which they are writing and effectively structured the content of their text(s); this identification appears to be a possible indicator of students' developing discursive competence appropriate for their participation in the FYE community.

In FYE, for the texts analyzed, rhetorical moves appear to occur within rhetorical spaces; an indicator of effective writing is whether students have appropriately identified the correct space for the rhetorical move they are making. At the macro-level, problem spaces and solution spaces are seen across the two genres and three assignments that I have analyzed: the technical brief (the Airplane Rodeo Assignment), the technical report (the Net Zero Energy Assignment), and the Final Design Project, which is also a technical report. Problem statements are just one of the discoursal components expected in the genre types identified, and with all three interviewees, problem statements are expected to be the first move of a text within the problem space. If the

discourse structure of any of these genre types leads with the solution space, or a move or step associated with the solution space, the text is rendered ineffective.

At first glance, the idea of a move-space discoursal relationship seems a bit novel; however, The Create a Research *Space* (CARS) model developed by Swales (1990) lends a genre purview of how writers are expected to create *spaces* within their texts and the possible applications for FYE. The content schema structure that Swales provided via the move-step analysis of introductions for research articles uses a framework of three moves followed by at least one step per move that writers expected to make: identifying territory (move 1), how authors carve out a niche within a territory (move 2), and how authors engage with a niche (move 3). The steps for each of these moves are associated with the use of various linguistic devices including, adverse sentence connectors, lexical negation, and/or negative quantifiers (e.g., *however*, *fail*, *overlook*, *little*). Following this framework, as students write introductions for the three genre types in FYE, they need to know how and when to create both a problem space and a solution space with the associated moves and steps.

Analysis of students' texts, the pedagogical materials, and the interview data, demonstrates that problem statements live in genres that are intended to be read by a wide-variety of audiences (often imagined), including potential clients, stakeholders, and users who may or may not have the same technical knowledge. These genres provide information about the potential client's needs (or problem), and the steps the engineer has taken to meet these needs and provide a relevant and meaningful solution. As such, the problem statement is generally expected to be the first move that students make when writing in ENGR 131, where they contextualize and define the problem they have addressed.

Interview data with Dr. Rodriguez, Dr. Reis, and Dr. Robins[4], elucidated the discourse structure expectations of texts in FYE wherein students need to effectively address problems and solutions. During our interviews, each participant was asked to identify the problem statement and provide an explanation for their decisions. Curiously, our conversations quickly gravitated towards understanding the differences and relationships between problems and solutions, and the importance of students dwelling on a problem without prematurely providing a solution. A rather significant benchmark for effective communication in FYE is being able to successfully discuss a problem without muddying it with language that suggests a preferred solution – this process of critically engaging with a problem is in large part the foundation of the FYE curriculum in which students are asked to assess information that is often incomplete, identify the competing demands of clients, and demonstrate technical competence. FYE's curricular framework mirrors that of problem-based learning: students are expected to develop discipline-specific knowledge through hands-on interaction with the environment and on-going social negotiation via collaborative learning. Problems thus become the anchor for learning in FYE. With problems as the anchor for learning, problem statements become an obvious tool for teaching content and procedural knowledge for design engineering. A genre-related approach to writing as a way to enhance knowledge (see Klein, 1999) appears to be implicitly applied in FYE via the pedagogical materials as a way to provide a function-form framework that aids students in the organization of their ideas and the rhetorical structure of their texts.

In chapter 3, I explained that for each of the interviews I provided sample student texts from the corpus. One reason for providing sample texts was so that faculty would have an opportunity to identify the problem statement in each of the three assignments; this process

[4] These names are pseudonyms for the interview participants.

provided critical insight regarding the rhetorical functions of problem statements, the linguistic features that bolster effective communication – or hinder it – and the expected rhetorical placement of problem statements. Figure 4.1 provides an example text from the third assignment, their Final Design Projects, which was used during my interview with Dr. Reis. The bolded text indicates where Dr. Reis identified the problem statement, and the un-bolded text is the shift to the solution. Along with Figure 4.1 is an excerpt from my interview with Dr. Reis. The text that is bolded aligns with the bolded text in Figure 4.1; the text that is green aligns with the green text in Figure 4.1; the text that is red aligns with the red text in Figure 4.1.

> **Dr. Reis:** …. Ok so I would say this [**bolded text** in Figure 4.1] is the problem statement and this is their criteria. Ok. Um. **So it depends on how we define the problem statement so you could say that this is problem statement and these are the criteria and constraints, the ones I have underlined,** [5]**but you could also include criteria and constraints as part of the problem statement too**, so I don't know how much you want to dig into that…I would say [the] problem statement basically explains what the problem is. So if you look at it from that perspective, this [bolded green text] is the context, it provides the context or who, client or user, what the client needs, a building, and these [bolded red text] are all umm criteria or specifications: it has to have four separate rooms, it needs to use net zero energy, it needs to use solar power, it needs to be comfortable, and there's a limited budget. So these are problem specifications; some of them are constraints like budget is a constraint. I don't know how strict it is but it sounds like it has to use solar power. **These are all part of the problem statement to**

[5] Portions of the interview are highlighted green or red to show where in the student example Dr. Reis identifies the problem statement and the criteria and constraints.

understand, so this paragraph explains what the problem is that needs to be solved.

> **The innovative alternative school system located in Eldoret, Kenya needs a laboratory building that has four separate rooms that will be designated for: motor vehicle mechanics, electrical, welding, and masonry. We must design this building, but it has to consume nearly zero energy by the end of 2020 and use energy from the sun to power the building without sacrificing the thermal comfort of the building's occupants and be considerate of the limited budget of the schools in that area.**
>
> Our solution was based upon meeting the criteria required by the client, energy efficiency, cost and desirability. Each team member individually designed a building. Using a weighted decision matrix we were able to determine the best option to use as our final design. We determined that Lab Building Alternative 3 was the best candidate for our final design. Using net energy, window-wall ratio, cost of construction, area of one lab, shrubbery, cost per square meter, and symmetry as our measurements of how well the criteria was met, Alternative 3 did the best job of covering those criteria by having the highest benchmarking score.

Figure 4.1 Student Example of a Problem Statement

According to Dr. Reis, a problem statement is considered effective when it clearly states who the client is and their general needs. The more specific information following the problem statement is identified as either *criteria* or *constraints*. However, depending on one's working knowledge and expertise, *criteria* and *constraints* may also be expected to appear in the problem statement, outlining additional, more specific information, such as budgetary concerns, energy consumption, and comfort, as in the student example in Figure 4.1. Dr. Reis noted elsewhere in the interview that as students began to discuss aspects of the solution, they were moving away from the problem statement.

Dr. Reis: …see it says "of *our* procedure" it is like it's *our* procedure, so each team [has] their *own* procedure.

AV: OK… so when the focus shifts from the client to the [engineer] designer?

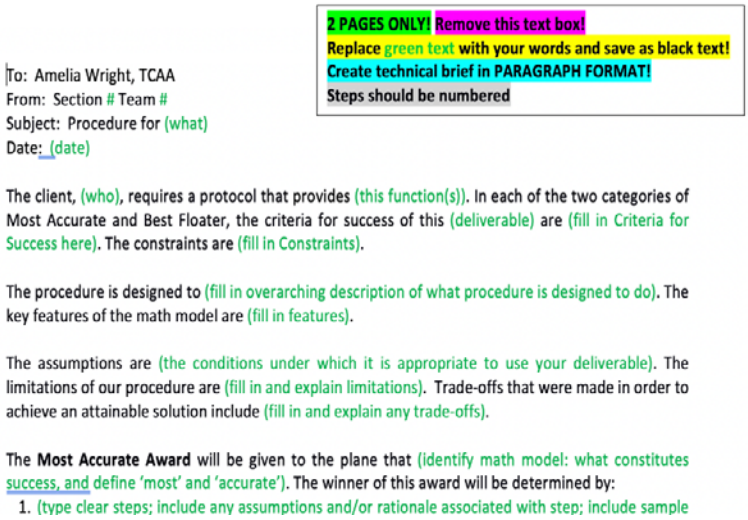
> **Dr. Reis:** …yes…I'm telling you that here's *my* solution and each solution is different; *this* solution will work under *these* conditions [limitations]…and basically this is how it will [work]…another way you can think about it is the client knows what this is [the problem statement], but the client doesn't know what this is [the solution].

Two additional boundaries for the problem statement that Dr. Reis noted were based on what the client knows (i.e., information provided to the engineer from the client is restated in the problem statement) and the use of the possessive pronoun *our* as a marker of language associated with the solutions (information the client does not have). Interestingly, this linguistic boundary is also seen in the pedagogical materials indicating a potential overlap with students' texts, especially since, as will be observed later in chapter 5, this linguistic feature is one that students maintain throughout all three assignments. This distinction between the problem and the solution is not always easy to disambiguate, particularly when students are expected to restate criteria and constraints later in the solution space as they outline the limitations of their proposed solutions and the trade-offs that were made in order to achieve their solutions.

> **Dr. Robins:** …so at a high level thing in terms of if you just think about here's a problem statement and a logic and here's solution and here's like recommendations**,** part of the reason [the problem statement] is a <u>blob</u> is that in talking about whatever your solution is you're talking about it in reference to that [problem]… and when you you're talking about problems you're already talking about solutions…

The "blob" that Dr. Robins is referring to here is the problem statement students write for their first assignment, The Airplane Rodeo, where a cloze-like, task-based activity is provided to

students with instructions to “fill in the blanks” with the correct information from supplementary materials (see Figure 4.2) wherein the content about the client’s needs are outlined. The Airplane Rodeo assignment is an introduction to problem statements and acts a scaffolding tool to orient students to engineering-specific language and the differences between problem-specific information and solution-specific information. Unfortunately, interview data suggests that the pedagogical materials may not be as useful as instructors would like.


2 PAGES ONLY! Remove this text box!
Replace green text with your words and save as black text!
Create technical brief in PARAGRAPH FORMAT!
Steps should be numbered

To: Amelia Wright, TCAA
From: Section # Team #
Subject: Procedure for (what)
Date: (date)

The client, (who), requires a protocol that provides (this function(s)). In each of the two categories of Most Accurate and Best Floater, the criteria for success of this (deliverable) are (fill in Criteria for Success here). The constraints are (fill in Constraints).

The procedure is designed to (fill in overarching description of what procedure is designed to do). The key features of the math model are (fill in features).

The assumptions are (the conditions under which it is appropriate to use your deliverable). The limitations of our procedure are (fill in and explain limitations). Trade-offs that were made in order to achieve an attainable solution include (fill in and explain any trade-offs).

The **Most Accurate Award** will be given to the plane that (identify math model: what constitutes success, and define ‘most’ and ‘accurate’). The winner of this award will be determined by:
1. (type clear steps; include any assumptions and/or rationale associated with step; include sample

Figure 4.2 Airplane Rode - The "Blob"

I note the distinctions between the problems and the solutions that faculty referenced because, as this chapter moves forward, much of the analyses and discussion will encompass how students engage with these spaces and how faculty perceive the effectiveness of students’ writing based on how they are, or are not, able to differentiate between problems and solutions. However, as I mentioned in chapter 3, the scope of my analyses is limited to the problem statement and the immediately surrounding text – generally the introduction to a genre type. These distinctions, the problem space and the solution space, also provide insight into instructor

expectations for writing and effective communication, and students' execution of these expectations.

4.2.2 Themes of Effective Communication

As I explained in chapter 3, I used an inductive analysis approach to analyze the interview data, wherein concepts for *effective communication* were derived from the raw data (see Thomas, 2006 for a discussion on inductive analysis of qualitative data), allowing me to observe frequent themes inherent in the interviews without the restraints imposed by more structured methodologies. Using NVivo, I read the interview data multiple times in order to develop the categories for effective communication. The objective, of course, was to identify how faculty perceive effective communication and any dominant similarities or disparities that arose between the three interviewees, the students' texts used during the interviews, and the pedagogical materials. The nine themes, or categories, for effective communication that emerged from the raw interview data are:

1. Audience Awareness
2. Specificity of Content & Data
3. Organization, Structure, & Logical Flow
4. Reflective Writing Strategies
5. Vocabulary & Discipline-specific Meanings
6. Impact of Pedagogical Materials
7. Clarity & Conciseness
8. Genre Conventions & Formality
9. Mechanics, Grammar, Punctuation, & Syntax

Table 4.1 provides information on the frequencies with which each code occurred in the interview data. *Vocabulary & Jargon* occurred the most frequently at 31.71% (n=39); interestingly, more than 50% (n= 21) of those codes were from my interview with Dr. Robins. The next three most frequently occurring codes were *Organization, Structure, & Logical Flow* at 20.32% (n=25), *Specificity of Content & Data* at 15% (n=18) and *Clarity & Conciseness* at 15% (n=18). The percentages here are out of 100% of the data coded; however, that does not account for the number of words coded in each instance. For example, two instances for *Audience Awareness* accounted for 600 words of coded data, while *Reflective Writing* accounted for a total of 582 words. While the table below funnels the codes from global to local concerns, it is important to bear in mind that these constructs are interdependent. As the data analysis will show, when faculty were discussing audience awareness they were also considering the role of vocabulary with discipline-specific meanings; as faculty were addressing organization, structure, and logical flow, they were also reflecting on the importance of specificity of content and the use of appropriate data and evidence for supporting an argument.

Table 4.1 Effective Communication Code Frequencies

Theme	Codes	# Of Codes in Data
Effective Communication	**Audience Awareness**	2 (1.63%)
	Organization, Structure, & Logical Flow	25 (20.32%)
	Genre Conventions & Formality	2 (1.63%)
	Specificity of Content & Data	18 (14.63%)
	Vocabulary & Discipline-specific Meanings	39 (31.71%)
	Clarity & Conciseness	18 (14.63%)
	Mechanics, Grammar, Punctuation, & Syntax	6 (4.88%)
	Reflective Writing	4 (3.25%)
Total Codes	123 (100%)	

4.2.2.1 Effective Communication: Audience Awareness

Summary: Audience Awareness, as a theme for effective communication, was most explicitly present across two of the interviews: Dr. Rodriguez and Dr. Robins. Both interview participants discussed the importance of being "sensitive" to the type of information difference audiences will need based on their involvement and investment in the design project. Dr. Rodriguez was more focused on differentiating between a "client" and a "user" and information that most benefits each potential reader; her explanation implied that different audiences may be more interested in solutions as opposed to problems, indicating that students will need to recognize who the potential readers are for each of the two possible spaces: the problem space and the solution space. Dr. Rodriguez explained that clients may likely be more interested in the process of developing the solution; an example she references is the "the economic viability" behind project, or how the project is produced, or where you purchase the product. In many instances, this focus on the product, and the criteria and constraints in place, is a direct link to the problem. For potential users, however, the focus shifts to "the good things" that a solution offers to a problem.

While Dr. Rodriguez focused on the practicality of audience awareness and identifying potential readers (and users), Dr. Robins provided an additional culturally-informed perspective when considering potential audiences, and argued that writers need to be aware of how their cultural backgrounds affect our language choices and how we communicate with others from diverse backgrounds –"we don't all talk the same way, we don't all use the same words." Her focus on cross-cultural communication, as she expressed it, is possibly a reflection of her interdisciplinary background. In fact, when Dr. Robins and I discussed language choices and audience awareness, our conversations often drifted back to the usefulness of certain requirements in place for FYE, particularly how first-year students engage with a new culture

(engineering and undergraduate matriculation) and whether or not the vocabulary in place actually benefit students as they are learning how to engage with problems and write problem statements.

To some degree, the pedagogical materials do address audience awareness; however, there is no explicit reference to cross-cultural communication. The pedagogical materials collected for the first assignment, The Airplane Rodeo, accentuate the perspective of the client while excluding potential stakeholders or users. Subsequent pedagogical materials for the Net Zero Energy and Final Design Report, however, provide what the handouts refer to as "problem-scoping" strategies where students are asked to identify additional potential audiences such as stakeholders and users (see Figure 4.3). Because The Airplane Rodeo is the first assignment, it is possible that students are being introduced to the concept of a client first, as a scaffolding technique. However, there are mentions of a potential user in students' texts when solutions are provided. Textual examples that illustrate students addressing audience awareness can be found in The Airplane Rodeo sub-corpus in which 411 out of the 427 texts reference the client as the audience for their technical brief, whereas only 11 concordance lines have the term "user" and only five of those instances are in reference to the direct user of their proposed solution; the remaining eight are noun-adjectives, "user-friendly." All instances of "user" occur in the solution space.

Much of this emphasis on audience awareness, according to Dr. Rodriguez, appears to be linked to justifying the project plan with adequate evidence; the evidence provided will depend on the audience (i.e., client vs. user). For example, perhaps the client would like to know the total cost of the project whereas a user may be more interested in the limitations of the product (e.g., how the product can and cannot be used). The student example below, for instance,

provides examples of criteria and constraints from the client's perspective; however, the solution space, where students begin to unpack the limitations and/or trade-offs, is where the user of the mathematical model they are designing is accounted for. It is possible then that, though the pedagogical materials for The Airplane Rodeo assignment do not specify that students address a user, the instructor of record has asked students to consider additional audiences.

Table 4.2 Audience Awareness Interview Data and Student Examples

Interview Data	Textual Examples
Dr. Rodriguez: And the other thing would be to be sensitive of what kind of information your different audiences need because if you are presenting the information to the client, probably the client would like to see all of the economic viability behind your project, right? or how you produce it or where will you buy things like the raw materials to make it, but if you're presenting it to the user, you're not gonna talk about those things, you're gonna talk about all the good things that your solution will have to solve the problem that the user has, right? So try to identify what's relevant for each audience.	**The client**, Amelia Wright and the TCAA, requires a protocol that provides accuracy and fairness in judging their competition. In each of the two categories of Most Accurate and Best Floater, the criteria for success of this judging format are a fair and accurate system that can judge both the floating ability and accuracy of the planes. Limitations and/or trade-offs that were made in order to achieve an attainable solution include the simplicity of our model. As we try to find a more suitable model, the more complicated it gets and would be hard for the judge or **user** to understand them.

Net Zero Energy Problem Scoping

1. Who is the client?
2. What are the needs of the client?
3. What is the overall **goal** of the Net Zero Energy design challenge?
4. Why is this goal an **important one**? Think both locally and globally.
5. List at least three possible stakeholders and users who could be impacted by your solution.
6. What are two competing needs of the stakeholders or users you have identified?
7. What are the design criteria with the Net Zero Energy design challenge?
8. What are the design constraints associated with the Net Zero Energy design challenge?

Figure 4.3 Audience Awareness Pedagogical Example

4.2.2.2 Effective Communication: Vocabulary & Discipline-specific Meanings

Summary: An important code that emerged frequently in the interview data was centered on the students' use language with discipline-specific meanings including *limitations*, *criteria*, *constraints*, *trade-offs*, and *assumptions*. During our interview, Dr. Robins referred to language with discipline-specific meaning as "engineering jargon" – and offered a bit of pushback against the use of jargon in first year engineering, suggesting that students would benefit from learning more general terms including, "restrictions" and "scope." Dr. Robins suggested that more general terms could possibly be more accessible to first-year students with a range of L1 backgrounds and assist in their transitions to engineering sub-disciplines. Much of Dr. Robins' pushback with the use of such language was largely a result of students' misusing the terms, leading to copious amounts of ineffective communication. During our interview, Dr. Robins

observed that students were “cueing” into the language provided in the pedagogical materials and attempting to demonstrate their knowledge of terms with discipline-specific meaning; this process of identifying the language they are expected to use for this particular genre is considered an effective, and useful, strategy for Dr. Robins. Conversely, the information that students provide to explain and demonstrate their understanding of these terms quickly becomes what Dr. Robins refers to as “gobbly guck” due to inaccurate use. “Gobbly guck” refers to the content and writing that students produce after the lexical sign-posts in place; students writing is perceived as unclear and often unrelated to the task(s) at hand. As result, students texts often lack the sophistication of discipline-specific knowledge and knowledge of genre conventions of which faculty are assessing.

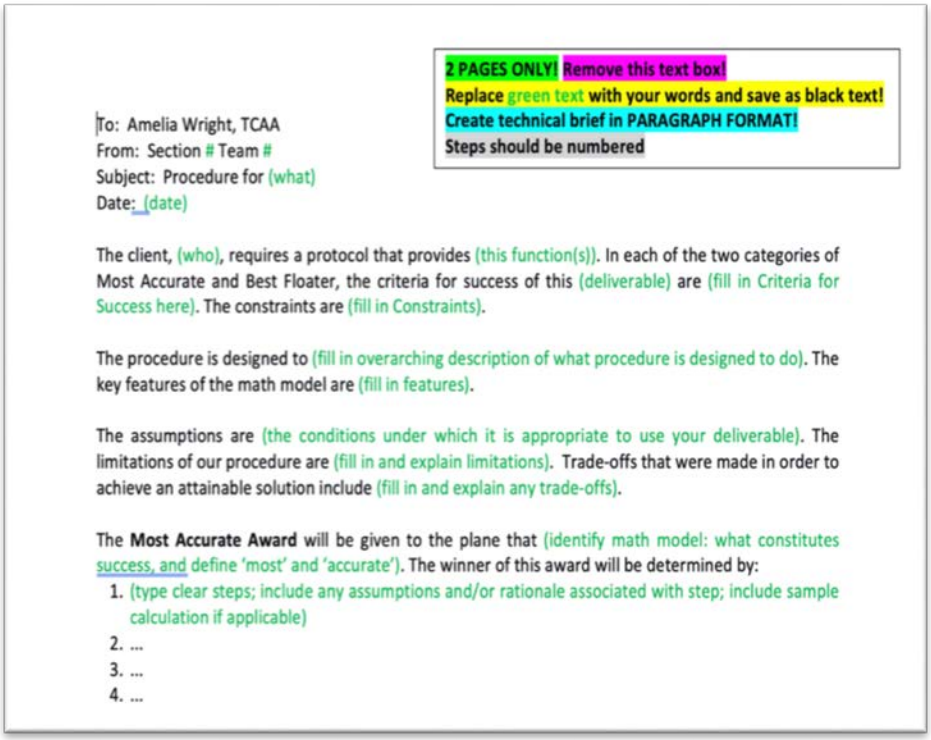
There is, for all interviewees, a direct link between accurately presenting conceptual and procedural knowledge and strategies for effective communication; those students who understand the terminology and the genre conventions of problem statements are by far assessed as more communicatively effective. Generally, however, students are observed as efficiently using the tools (from the pedagogical materials) but they are failing to internalize the new content knowledge, leading to students blindly relying on pedagogical materials.

Table 4.3 provides an excerpt of the interview data with Dr. Robins with the textual example Dr. Robins was referencing at the time; Figure 4.4 is the template students use to write the technical brief for their Airplane Rodeo Assignment. The underlined text in the student example highlights the language students directly pulled from the pedagogical materials (Figure 4.4), the word cues that Dr. Robins finds to be effective sign-posts as a reader. The writing that students provide after the bolded text is what she refers to as “gobbly guck.” For example, when students begin to define constraints, Dr. Robins identifies *technology, reaction or human error,*

and time as constructs that are not actually constraints, largely because these constructs are not measurable and are too abstract. As students move towards the solution, however, students are identified as increasing the accuracy with which they demonstrate conceptual knowledge. Overall, all participants agreed that students were better able to demonstrate the development of conceptual knowledge when writing in the solution space but demonstrate more inaccuracies with conceptual and procedural knowledge in the problem-space as they write their problem statements.

Table 4.3 Vocabulary & Discipline-specific Meaning Interview Data and Student Example

Interview Data	Textual Examples
Dr. Robins: "I wouldn't call it effective. I would…what I see are a bunch of word cues. Like they picked up on **word cues** and then it's a little bit of gobbly guck. Probably the parts that are most effective are the use of the words, the [pedagogical] language [like] limitations, that these are things that count as kinds of limitations. And that's probably where the lack of clarity comes in. The things that would count as criteria aren't necessarily there. The things that would count as constraints aren't necessarily there. Um. The things that would count as trade-offs, I mean there's a quality of the language in here, there's this sort of "more" "less" kind of trade-off-y thing so they're kind of in the right conceptual space…"	**The client,** Amelia Wright, President of Twin Cities Aviation Association, requires a protocol that provides a method to accurately determine the winner of a competition based on flight of the planes. **In each of the two categories of Most Accurate and Best Floater, the criteria for success of** this contest are time, distance, final location, and angle of the plane and the target. **The constraints are** technology, reaction or human error, and time. **The procedure is designed to** fairly determine the winner of the airplane rodeo through objective and uniform measurements. The key features of the math model are distance from the starting point… **The assumptions are that** the measurements will be accurate, the throwers are unbiased and the same throughout, the throwers start at the same location…**The limitations of our procedure are** inaccurate…



2 PAGES ONLY! Remove this text box!
Replace green text with your words and save as black text!
Create technical brief in PARAGRAPH FORMAT!
Steps should be numbered

To: Amelia Wright, TCAA
From: Section # Team #
Subject: Procedure for (what)
Date: (date)

The client, (who), requires a protocol that provides (this function(s)). In each of the two categories of Most Accurate and Best Floater, the criteria for success of this (deliverable) are (fill in Criteria for Success here). The constraints are (fill in Constraints).

The procedure is designed to (fill in overarching description of what procedure is designed to do). The key features of the math model are (fill in features).

The assumptions are (the conditions under which it is appropriate to use your deliverable). The limitations of our procedure are (fill in and explain limitations). Trade-offs that were made in order to achieve an attainable solution include (fill in and explain any trade-offs).

The **Most Accurate Award** will be given to the plane that (identify math model: what constitutes success, and define 'most' and 'accurate'). The winner of this award will be determined by:

1. (type clear steps; include any assumptions and/or rationale associated with step; include sample calculation if applicable)
2. ...
3. ...
4. ...

Figure 4.4 Pedagogical Example: Vocabulary & Discipline-specific Meaning

4.2.2.3 Effective Communication: Specificity of Content & Data

Summary: One area that all interviewee participants agreed increased effective communication was specificity of content and use of qualifiers that indicate measurable content (with associated and appropriate data). According to Dr. Reis, criteria and constraints are aspects of a final object that an engineer can measure; this is particularly critical for logic and argumentation as well when students are asked to demonstrate how they met (or failed to meet) the criteria and constraints in the description of their solution (i.e., limitations and trade-offs). When students provide vague constraints such as "technology" and "reaction or human error" (as seen in student example in Table 4.3), their writing is identified as confusing and unclear. "Technology", in this instance, is not easily measurable because it is too vague and abstract; effective writing strategies would instead provide detailed specifications about the technology students have in mind and

how it would benefit the client. One anecdotal example that Dr. Robins provided in her interview for an effective constraint addressed the degree to which a device (i.e., a cellphone, a watch, a camera, etc) is waterproof and under a certain cost. If a client indicates that they need a device that is waterproof, the engineer can design a product that meets the constraints, but then indicate the limitations in the solution (i.e., the device is waterproof *up to* 5 feet). Identifying an acceptable measure for being waterproof would be established with research, where the engineer then justifies their decision.

In the example below, Dr. Reis, much like Dr. Robins, found the students' description of criteria and constraints confusing; while Dr. Reis mentions in this excerpt of her interview that students should provide examples that are measurable, in order to demonstrate in the solution space how these criteria and constraints were (or were not) met, Dr. Robins, as I highlighted above, connects this lack of specificity of content and data to students' limited internalized understanding of language with discipline-specific meanings. The pedagogical example in Figure 4.5 provides a working definition for both constraints and criteria. One difference that Dr. Robins highlighted between criteria and constraints is that constraints are criteria that are non-negotiable, while criteria are negotiable; the pedagogical materials reflect this distinction. Additionally, Dr. Robins further articulated that, for her, everything is negotiable; as a result, if students confuse criteria and constraints in their writing, she does not immediately consider their texts ineffective.

Table 4.4 Specificity of Content & Data Interview Data and Textual Example

Interview Data	Textual Examples
Dr. Reis: "…criteria and constraints should be things that you can **measure**. Are they there or are they not there? Did you meet them or did you not meet them? And so this is a little bit confusing [be]cause I don't know what that means."	The client, Amelia Wright, President of Twin Cities Aviation Association, requires a protocol that provides a method to accurately determine the winner of a competition based on flight of the planes. In each of the two categories of Most Accurate and Best Floater, the **criteria** for success of this contest are **time**, **distance**, **final location**, and **angle** of the plane and the **target**. The **constraints** are **technology**, **reaction or human error**, and **time**.

Constraints	Specifications that limit how a problem can be solved. In engineering design, constraints are used to evaluate potential design solutions. They are criteria that ***must*** be met. Constraints include budget, time, human resources, dimensions, etc.
Criteria (pl) **Criterion (s)**	A standard of judgment, or a rule or principle for evaluating something, such as potential design solutions. Criteria help you to choose between options. Criteria should be **clear and measurable**

Figure 4.5 Pedagogical Example Specificity of Content & Data

4.2.2.4 Effective Communication: Reflective Writing

Summary: An interesting code that emerged during the analysis was the concept of reflective writing as a component in students' texts. This was also an area that generate quite a bit of disagreement between faculty on whether or not reflective writing was an appropriate component for the genres that students are asked to write. Reflective writing refers to when students engage in a reflective process about the design process; reflective writing was generally observed in the last two assignments: The Net Zero Energy assignment and The Final Design Project. For Dr. Robins, reflection is a critical activity with which she expects engineering students to engage; she particularly finds this beneficial for emerging engineers who are grappling with new

concepts and procedures, noting that students should reflect on both the problem and the solution and the two are interconnected. In her classrooms, Dr. Robins often asks students to go beyond surface commentary and unpack the difficulties and challenges that they encountered as they worked through problems for potential clients. This type of reflective and descriptive engagement is viewed as part of the knowledge building process, particularly for fostering critical thinking skills. Dr. Robins finds this reflective process beneficial for both students and teachers because teachers are able to identify gaps, and progress, in students' knowledge development and students are able to engage with the process on a more concrete level. What is interesting is that Dr. Robins acknowledges that "there are different genres for writing," indicating that reflective writing has different genre conventions when compared to technical reports; however, perhaps because this is an educational context and not a professional one, Dr. Robins prefers students to engage with both genre conventions for their writing assignments; it is possible, however, that this strategy is not effective pedagogically.

Dr. Reis and Dr. Rodriguez, however, prefer that students refrain from "journal-like writing" for formal documents such as technical reports and technical briefs; perhaps this reflective process is beneficial for students and teachers, but Dr. Rodriguez finds both inappropriate and ineffective from the client's perspective. Rather than encouraging students to divulge their entire processes in what is meant to be a concise summary, Dr. Rodriguez believes reflective writing would be most beneficial as a separate activity and document, maintaining her original stance that students should be aware of their audience and what information is essential. This is not to say that Dr. Rodriguez does not value introspection or the importance of identifying the lessons learned, but rather that the genre conventions for formal, client-oriented documents, do not provide space for reflection. Conversely, based on the pedagogical materials

(Figure 4.6), however, “Process Reflection” is expected to occur at the end of their document (for the second and third assignments) where students discuss key iterations or changes made during the design process as well as the limitations of their approach (not the same as the limitations of their object); yet, students often, like the example below, engaged in reflective writing while they were discussing the key limitations, trade-offs, and assumptions they made that resulted in their final product. In the student example in Table 4.5, students opted to provide the reflection on their design process as part of their executive summary directly following their problem statement.

Table 4.5 Reflective Writing Interview Data and Student Example

Interview Data	Textual Examples
Dr. Robins: Um. There are different genres for writing. And so for the reflective questions I’ll be looking for you know that there’s, that they move beyond just a description of the experience to talking about um how that made them feel, how that made them think about something differently so that there’s some um there’s the reflection part back of um you know what insight did they gain from that and what might they do differently next time kind of thing vs just like yea that was really hard *laughs* you’re like awesome but why was it hard what would you do next time and what do you think is going on. **Dr. Rodriguez:** and they tend to do this a lot, kind of write it as a journal *laughs* we did this first and it didn’t work and then we did this and then we did this... it’s a summary you don’t tell your client all the ups and downs that you had *laughs* you can have a lessons learned like that later *laughs*	When creating the model we initially wanted to provide a model that would be fully able to tell a customer, based on limited customer provided information, the optimal maintenance schedule for any building. The desire was for a model to apply to buildings ranging from offices to convention centers to schools. The reality was that this was impossible with our data set. In creating the model we slowly had to add more and more assumptions, the biggest of which is that we are assuming the customer itself is looking to update maintenance schedules for a building with a similar purpose and usage style consistent with the Neil Armstrong Hall of Engineering. This was where our data came from and there was no reliable way to extrapolate this data and apply it to any other type of building. So overall the model assumes that the bathrooms of the customer are equal number male and female restrooms, and that the layout is close to a ratio of 5 stalls per female restroom, with 3 stalls and 2 urinals in each male restroom, scaling relative to the population of the building…With this level of assumptions we are aware that the model begins to lose its utility, but we were working with the data handed to us… To that end the model we did create is described below.

B. Final Report

Not all work or documentation you have prepared will be shared in the video. The purpose of the final report is to share mode detail as well as additional information about **your design process** with the instructional team. In many ways this document shares your "background story" of how you reached your solution.

Using previous milestones and feedback, write a Supplemental Document that describes:

i. Executive Summary – summarize key points and address:
   - Problem Statement
   - Your team's solution and how well it meets key design criteria and constraints
   - Evidence on the design optimization efforts on your final solution, the trade-offs made to reach the solution, and the limitations of the solution

ii. Value Proposition (Milestone 6)

iii. Detailed final solution
   - how it functions and evidence of feasibility (state any assumptions made)
   - Alignment between final solution and how that solution meets client and user needs

iv. Details of your experimentation and data analysis (Milestones 3, 4 and 5)

v. Optimization - Trade-offs and improvements made to chosen solution

vi. Process Reflection- discuss any key iterations, changes or pivot points in the direction of your project, limitations in your approach and how the process was impacted.

Your report should be no more than 2 pages (Additional figures can go in the appendix BUT every figure in your document – whether in the appendix or not – needs to be referenced in text, i.e. if you do not talk about the figure, do not put it in the report document.

Use single spaced, 11 pt, Calibri font.

There should be a title page in your report document (details are given in the D bullet point at the beginning of this document).

Figure 4.6 Pedagogical Example: Reflective Writing

4.2.2.5 Effective Communication: Organization, Structure, & Logical Flow

Summary: Organization, Structure, & Logical Flow relates to how the information is organized and the validity of the arguments students make as they contextualize the importance of their problem or argue for the efficacy of their solution(s) to a client's problem. In the example here, Dr. Robins and I engaged in a conversation about appropriate structures and strategies for relaying information; specifically, Dr. Robins proposed an open-ended question on the effectiveness of narration as opposed to bullets or figures when describing criteria and constraints. Our conversation began when I asked if it would be more effective for students to use commas or semi-colons instead of periods when listing the constraints as a way to indicate the boundaries of the constraints. As Dr. Robins weighed the benefits of teaching students other

approaches of presenting and formatting information (i.e., bullet points and figures), she explored how potential readers experience this and process this information based on how the information is structured and organized.

In many ways, Dr. Robins was implicitly questioning the genre conventions taught with the assignments students were asked to write and how these conventions influenced the effectiveness of students' texts. She identifies that students' choice to write narratives instead of bullet points for criteria and constraints is possibly "part of the scaffolding issue." She suggests that students using a narrative format is a carryover from other contexts and assignments, and ultimately brings up a distinction between the writing done in my "space" or in the humanities, and writing produced in engineering disciplines. Dr. Robins remarks on how attuned humanities is to the different formats that exist for different genres and reflects on how "we [engineers] forget we have like a whole bunch of tools that effectively communicates the kind of information that's here." This open-ended question led to a discussion on the best practices for teaching the conventions for discipline-specific genres including problem statements whether or not the pedagogical materials effectively reflect the instinctual expectations faculty like Dr. Robins have when reading similar genres with similar data points.

Interestingly, when observing the pedagogical materials for this specific assignment (see Figure 4.7), the handout provides students with the bulleted information for constraints and limitations for the solution, which appears in their own writing; rather than following the design and format in the handout, students opted to put the information in a narrative format – the carryover that Dr. Robins was referring to during her interview. Additionally, students made no edits or revisions to the wording from the pedagogical materials; rather, students likely copied

and pasted from the handout, maintaining even the original punctuation that I was addressing in my original question to Dr. Robins.

Table 4.6 Organization, Structure, & Logical Flow Interview Data and Student Examples

Interview Data	Textual Examples
AV: would it be better if these [periods] were commas? **Dr. Robins:** see this is where, I'm struggling with narrative vs. bullets. Right. Just because the logic of it, you know these get to be separate elements, and when they're in the narrative that's when you're kind of saying like commas, is just a big blob. Um Whether or not that's the smartest way ever, I don't know, but that might be part of the scaffolding issue. **AV:** So thinking of a way to convey a lot of information … **Dr. Robins:** yea, and you know all of this, and I mean I think this is just a carryover from stuff, all of this is written as text but I would imagine your space you would be like what about a figure you know? What about a table? What about a thing that's like here's my criteria and constraints and here's like the extent to which I met them, right? And so it's like we forget that we have like a whole bunch of other tools that effectively communicates the kind of information that's here. And this is written as narrative, paragraphs. So I don't.. that's kind of my open question. I don't know.	The client, Purdue University, wants a net zero energy apartment building that is capable of housing 16 students. The constraints are that **each side of the apartment building must have at least two windows on each floor.** The **tree trunks must be at least two meters away from the building. Solar panels cannot hang over roof edges or be mounted to the walls. All windows and walls must be of the same material. Each apartment must have four bedrooms, two bathrooms, a common kitchen and a living room.** The criteria are that the house must be energy efficient meaning that the net energy over the year must be equal to or less than zero. The house must be attractive and the cost must be under $425,000.

Constraints

In addition, the following limitations exist:

- Each side of the apartment building must have at least two windows on each floor.
- Tree trunks must be at least two meters away from the building.

Note: *Design challenge associated with NSF DUE # 1348547 & 1348530. Purzer (PI) & Adams (co-PI) modifications by Jimenez and Purzer (Spring 2017)*

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ENGR 131 **A12 & 13: Net Zero Energy Challenge** **Fall 2017**

Design of a Zero-Energy Apartment Building

- Solar panels cannot hang over roof edges or be mounted to the walls.
- All windows must be of the same material.
- All walls must be of the same material.
- Each apartment must have four bedrooms, two bathrooms, and a common kitchen and living room.
- A building is defined as a space enclosed by one and only one set of connected walls.
  - **You can only create one building on a single platform** (do not put multiple buildings on the platform).
  - Do not add entry porches, dormers, chimneys, garages, or driveways.
  - Do not include interior walls. The design/layout of the interior is not important at this stage of the proposal process.

Always document your work, especially your analyses about the energy performance, in the ***Notes*** area in the Energy3D. Your notes are saved automatically when you save the design.

Figure 4.7 Pedagogical Example: Organization & Structure

Another aspect of *Organization, Structure, & Logical Flow* is how students demonstrate a logical solution to a problem with which they have been presented. For instance, Dr. Rodriguez provided anecdotal examples of how problem statements act as tools to assess students' logical progression towards a solution and the coherence of their overall argument(s):

> **Dr. Rodriguez:** …the other thing that I think is important in engineering is that the logic checks. So that you have a coherent story, again, this idea of my problem that these kids are bored, and my solution is a stove *laughs* right? Like that the

> logic [should] check that you have a round story, *this* was the problem, *this* was the solution *these* are the data that back up why *this* solution is the best solution right? All that logic that goes into place.

Here, Dr. Rodriguez indicated that students were able to assess the usefulness of their solution after they were asked to reread their problem statement directly followed by their final proposed solution (which is often expected to be articulated later). The assignment sequence that Dr. Rodriguez was referring to is unclear; however, it was after The Airplane Assignment and very likely a final project. Either way, Figure 4.8 is an example of the target learning objectives for assignments. As a reminder, a problem statement is a rhetorical move that appears in the executive summary. I selected this example of a peer-review rubric to highlight that "logic" is not language that is found in relation to students' writing, but more so in relation to students' conceptual ideas and proposed solutions; rather, students are asked to justify and provide evidence, or reasons, for their decisions. The pedagogical materials most frequently address these more global concerns that Dr. Rodriguez mentioned in her interview than the language students use to perform these skills. For Dr. Robins, however, she assessed the logic of students' writing based on the accuracy with which students filled in the "buckets," and effectively used the language in the template from the first assignment, The Airplane Rodeo, as sign posts. For Dr. Robins, logic at the sentence and paragraph level is inextricably linked to the degree to which students understand and internalize language with discipline-specific meanings (e.g., criteria, constraints, etc.).

Table 4.7 Organization, Structure, & Logical Flow Interview Data and Student Example

Interview Data	Textual Examples
Dr. Robins: Yea… I'm trying to figure like it starts to kind of um…so it's in the range of 'clear'…there are things about it. They've put boxes with other boxes you know? They've made connections with other things…Then some of that is clear, some of it I don't know what that is, some of it I don't know if it's in the right box, so it's sort of like the logic is starting to fall apart. **AV**: What's not in the right box? **Dr. Robins**: Well you know, it's like I said the constraints are 'technology' 'human error' and 'time' and so it's like I think they might actually be using constraints [as] limitations.	**The client,** Amelia Wright, President of Twin Cities Aviation Association, requires a protocol that provides a method to accurately determine the winner of a competition based on flight of the planes. **In each of the two categories of Most Accurate and Best Floater, the criteria for success of** this contest are time, distance, final location, and angle of the plane and the target. **The constraints are** technology, reaction or human error, and time. **The procedure is designed to** fairly determine the winner of the airplane rodeo through objective and uniform measurements. The key features of the math model are distance from the starting point… **The assumptions are that** the measurements will be accurate, the throwers are unbiased and the same throughout, the throwers start at the same location…**The limitations of our procedure are** inaccurate…

Target Learning Objective	Area of Review
PC02: Make statement to communicate results found in analysis	• Executive summary
SQ03: To justify qualities of a solution and recognize any limitations, explain the trade-offs made to arrive at a final solution.	• Executive summary
SQ01: Use accurate scientific mathematical and/or technical concepts units and/or data in solution	• Executive summary • Energy Analysis • Cost Analysis
EB03: Make explicit reference to data when explaining trends, justifying decisions, or making comparisons.	• Executive summary o Energy Data o Cost Data o Conclusion
EB06: Clearly articulate reasons for answers when making decisions or evaluating alternative solutions.	• Executive summary o Ease of construction o Curb Appeal
SQ02: Justify design solution based on how well it meets criteria and constraints.	• Executive summary o Comfort explanation • Section II: Attractiveness and Desirability Analysis
PA02: Identify limitations in the problem solving/design approach used.	• Executive summary o Conclusion

Figure 4.8 Organization, Structure, & Logical Flow Pedagogical Example

4.2.2.6 Effective Communication: Impact of Pedagogical Materials

Summary: Much of the data up to this point has highlighted a relationship between perceptions of effective communication and the pedagogical materials. The instances where pedagogical materials were referred to by faculty while they were discussion other aspects of effectively communication, I did not code them as impact of pedagogical materials. Interview data coded under *Impact of Pedagogical Materials* were explicit references where faculty identified potential interactions between the writing students produced and how FYE scaffolds problems.

At one point or another, all three faculty often commented on the limited usefulness of the pedagogical materials, whether it was because students relied too much on the information provided to them, copying and pasting content from handouts into their writing without any evidence of internalizing new knowledge, or because the pedagogical materials negatively impacted the ways in which students approached problems.

For Dr. Reis, the usefulness of the pedagogical materials is largely assessed by the types of problems with which students are asked to engage. When students are asked to solve problems that are "very open" or "open-ended," students generally have "ill-defined problem statements," which are more difficult for instructors to assess – both in terms of writing and content. In my interview with Dr. Rodriguez, it was difficult to ascertain whether or not she found the formulas provided in the first assignment, The Airplane Rodeo, beneficial for students, particularly when considering whether or not students should maintain the prescriptive formula provided or demonstrate their internationalization of new knowledge via paraphrasing and summarizing important information in their own words. For instance, at one point, Dr. Rodriguez indicates that she would "rather they say it in their own words." A few lines later, however, when I check for clarification, she suggests that perhaps paraphrasing is a higher-order skill that she does not actually expect students to perform – "In these assignments, we don't go that far…we just want them to hit the elements of the problem statement." This is a similar sentiment of Dr. Robins' when she discusses how students "fill in the buckets" and "cue into language" provided in the pedagogical materials. Dr. Rodriguez then highlights the differences between "proficient" and "developmental" on the rubric, indicating the differences between merely stating the criteria and constraints versus defining criteria and constraints with measurable language and content.

Table 4.8 provides interview data with Rodriguez, a student example from The Airplane Rodeo sub-corpus used during her interview, and Figure 4.9 provides an example of a rubric from The Final Design Project. While the rubric in this example is not from the first assignment (there was not a rubric for The Airplane Rodeo in my dataset), it does provide evidence of how students are assessed in terms of their writing, highlighting what appear to be four central elements for the first two rhetorical moves students are asked to make in each of the genres in the corpus: (a) Context & Need, (b) Problem Scoping & Need Justification, (c) Detailing Selected Solution, and (d) Solution Quality are addressed and assessed in the final assignment. Based on the descriptions provided in the rubric (e.g., proficient, developing, emerging, and missing), it appears that the problem statement falls within two of the categories: (a) Context & Need and (b) Problem Scoping & Need Justification. As assignments become more open-ended, students are asked to critically engage with the context, both globally and locally, of the problem and the solution, strengthening their justifications and rationale for the problem at hand with outside sources that support the requirements (e.g., criteria and constraints) of a possible solution.

Dr. Rodriguez finds the student example in Table 4.8 effective because students took the time to interpret the terms and constructs in the pedagogical materials (e.g., fair and bias) into their own words – a step further than students are expected to go in the first assignment, The Airplane Rodeo. This first assignment, as Dr. Rodriguez and the other two interviewees pointed out, acts as a scaffolding tool to introduce students to the concept of problem statements and how to affectively and effectively approach problems and solutions. The differences between being “proficient” writers and “developmental” writers comes down to whether students are able to explain, in their own words, and define what the criteria and constraints are with appropriate data points. “Developmental” writers, according to Dr. Rodriguez, are those students who list, or

copy/paste, from the pedagogical materials. The rubric example in Figure 4.9 does not confirm Dr. Rodriguez' perspective of proficient vs developmental writers.

Table 4.8 Impact of Pedagogical Materials Interview Data & Student Example

Interview Data	Textual Examples
AV: So, you don't want them to repeat exactly what you've give them… **Dr. Rodriguez**: they can … because… I mean I know what I put in the problem right, but if it's their take on the problem I would rather that they say it in their own words. So, for example, this one said um the criteria for success was that all external factors that could lead to inaccuracy are eliminated… right? That means kind of being fair or not being bias which are the words we gave them in the assignment, but they took the time to interpret that. **AV**: So, you kind of like you give them formulas, right? and they fill in the blanks and the part that they fill in the blanks you want them to take the information that you've given them and kind of paraphrase it and use their own words? **Dr. Rodriguez**: In these assignments we don't go that far… we just want them to hit the elements of the problem statement *laughs* but yea, actually if you look at the rubrics that we have one of the levels that is um highest proficient it says it explains the criteria and constraints and I think the developmental is it just lists the criteria and constraints as we give it to them, something like that.	The client, Amelia Wright, requires a protocol that provides a judgement deciding the most accurate and best floater in the fairest way. In each of the two categories, Most Accurate and Best Floater, **the criteria for success was that all external factors that could lead to inaccuracy are eliminated and that the same judging method is used for all planes in an effort to find a worthy winner in a fair and just manner.** The constraints are that planes are affected by air resistance, varying force at which the throwers throw each plane, wind speed, as well as thrower fatigue.

Goal: Convince the Kimberly-Clark review committee that your team identified a relevant need and selected the best solution.

	Proficient	Developing	Emerging	Missing	Total
Context & Need (2 points)	• *Describes in detail the context for the need* • *Explains how this is a local and global need* • *Identifies target user*	*Provides some details of the larger context and some sense of which need is addressed*	*Provides few details of the context and/or a vague sense of what need is addressed*	*There are no details of the context and it is unclear what need is addressed*	
Problem Scoping & Need Justification (2 points)	• *There is a clear problem goal statement that communicates the need and the goal(s)* • *Provides a rationale for this unmet need* • *Summarizes criteria and constraints*	*Partially captures the scope of the problem—presents a need, but the importance of the need is not well-defined.*	*Justification for current options is* ***anecdotal*** *with no supporting evidence.*	*There is no problem scoping, (no mention of needs or justification for its importance).*	
Detailing Selected Solution (3 points)	• *There is a* ***professional model*** *of the solution that explains key elements of solution and how it works.* • ***Innovative qualities*** *(unique features & strengths) are highlighted* • ***Weaknesses*** *and assumptions are discussed*	*There is a visual representation of the selected solution but it is not very useful or* ***no*** *discussion of* ***unique features, strengths & weaknesses.***	*Not enough* ***information to understand*** *what the selected solution is and how it works.*	*There is no selected design.*	
Solution Quality 1 (3 points)	• *Solution is exemplary and provides an* ***engineering solution*** *that addresses criteria and constraints*	*Solution addresses only* ***two aspects of criteria and constraints fully OR*** *solution only* ***partially addresses three or more criteria and constraints*** *Team developed an* ***engineering solution*** *that addressed the need*	*solution only* ***fully addresses one criterion or constraint OR*** *solution only* ***partially addresses two criteria and constraints*** *Solution creates* ***new problems.***	*Solution is irrelevant.*	

Figure 4.9 Pedagogical Example: Rubric for Final Assignment: Kimberly Clark

4.2.2.7 Effective Communication: Clarity & Conciseness

Summary: Clarity & Conciseness is a coded feature of *Style*. As a feature of effective communication, *Clarity & Conciseness* often overlaps and impacts the other eight elements of effective communication. Several pedagogical materials indicate that writing should be "clear and concise;" the example from Figure 4.10 defines "clear and concise" writing as having "no extraneous information." According to Dr. Reis (as seen in Table 4.9), clarity and conciseness are impacted by the degree to which students understand discipline-specific terms (e.g., criteria and constraints). If students have a difficult time unpacking and defining these terms, their writing is perceived as vague and often inundated with "extraneous information" (which is perhaps also a reference to what Dr. Robins' calls "gobble guck") in their efforts to write towards understanding. For example, as Dr. Reis was reading and assessing students' writing

during our interview, she commented on students' conceptualization of criteria that she felt were unclear, particularly because she was uncertain whether or not students understood the criteria they were listing: **minimizing wastage of soap**, **maximizing cleaning productivity**, and **time spent cleaning**. For Dr. Reis, an important part of clarity and conciseness is including language that speaks to the metrics of criteria and constraints (i.e., specificity of content and metrics); because students did not include any measurements (i.e., *how* does one minimize wastage of soap and maximize cleaning productivity), their writing is assessed as vague. In general, Dr. Reis found the example below to be redundant with unclear goals and requirements for a potential solution.

Dr. Robins generally agrees with Dr. Reis in terms of clarity. Dr. Robins says "I always have on my rubric this whole thing about *professional communication* and so you know a lot of it is about…*clarity of thought*, *clarity of exposition*…" For Dr. Robins, professional communication is linked to a "user-audience mentality" where she encourages students to consider who their readers are and whether or not their readers will understand the main idea(s) of the text. For Dr. Robins, this "user-audience mentality" is directly linked to concepts of clarity and conciseness.

Based on the interview data, clarity and conciseness is directly linked with students understanding discipline-specific meanings of frequently used vocabulary and appropriate audience awareness.

Table 4.9 Clarity & Conciseness Interview Data & Student Example

Interview Data	Textual Examples
AV: "Ok. Well, as it stands, except for this right here, it is mostly redundant, and it is unclear?" **Dr. Reis:** "Yea. It is like…if we use this heuristic of how much do I understand the problem? like, I'm still asking how we *reads text* Ok so **these are the criteria, but I'm not sure how well they understand what these terms mean and it's not clear so they are very vague**.	…This schedule should be modifiable to account for restrooms in different buildings, but should also manage to maintain a proper standard of hygiene in the restrooms while **minimizing wastage** of soap, toilet paper and paper towels, and **maximizing cleaning productivity** of the cleaning staff while at the same time minimizing the amount of **time spent cleaning.**

5. A high quality model is sharable. A user can easily apply the model (or procedure) and replicate results. A user can also easily enter new input data or starting conditions. The writing is clear and concise; there is no extraneous information. Evidence that the procedure works is provided in the form of a complete set of results with correct significant figures and units.

Figure 4.10 Clarity & Conciseness: Pedagogical material for peer-review

4.2.2.8 Effective Communication: Genre Conventions & Formality

Summary: Genre Conventions & Formality is another element of effective communication that emerged from the data. For Dr. Reis, formality appears to be connected to register (spoken vs. written) in that she remarks on how students are "writing like they are talking." A key linguistic feature that is evidence of students' lack of formality and operating within a less desired register is the use of non-referential pronouns (i.e., *this*, *that*, *it*). Dr. Reis identifies the textual example below as lacking strong communication skills because the students fail to communicate explicitly and clearly, requiring the reader to infer and re-read previous sentences. Like many of the other codes, formality is not discrete; the degree to which students' writing is assessed as "professional" and "appropriate for engineering school and workplace," as indicated in the rubric in Figure 4.11, impacts the clarity and conciseness of students' writing. Interestingly, while all

three interviewees discussed the importance of “professional communication,” Dr. Reis was the only interviewee to explicitly discuss formality while also explicitly linking formality to a linguistic feature; for the other interviewees, they expressed grievances with students’ uses non-referential pronouns and the impact non-referential pronouns have on clarity and conciseness, but they did not state whether or not non-referential pronouns were or were not considered an element of a “formal tone” and “appropriate for engineering school and workplace."

Table 4.10 Genre Conventions & Formality Interview Data and Student Examples

Interview Data	Textual Examples
Dr. Reis: “…so it [problem statement] ends here [and] they start the solution space here. **The communication is not strong on this one.** **AV:** “Why is that?” **Dr. Reis:** “So what …**this was a key trade-off** …what? [this is unclear]. I don’t like the paragraph starting with [this]…the very sort of everyday language; they are writing like they are talking.	…***This was a key trade-off.*** After optimizing the selected design as best as we could within the limitations of the program we were left with a building that had a net energy of about -1700 kWh, which was the least energy efficient of our options. ***This*** **didn’t matter in the final decision though** because…”

Your work will be graded on completion of the following objectives:

- PA01: Identify strengths in problem solving/design approach.
- PA02: Identify limitations in the approach used.
- PC01: Use professional communication (written, visual, and oral), free of grammatical or spelling mistakes and in a formal tone, appropriate for engineering school and workplace.

Figure 4.11 Style: Formality/Register Pedagogical Material Example

4.2.2.9 Effective Communication: Mechanics, Grammar, Punctuation, & Syntax

Summary: Mechanics, Grammar, Punctuation, & Syntax is another element of effective communication upon which the interview participants reflected. Often, the interviewees were disgruntled by students submitting their final drafts without revising for spelling and grammar. For Dr. Robins, spell check and grammar check are the "easy ones" for students, yet they often ignore these aspects of their writing. Dr. Rodriguez reflected on how both L1 and L2 students often had difficulties with grammar and syntax, but she was able to note that she can often identify when students whose first language is not English have translated from their first language to English, "because … this structure just doesn't make sense in English." In addition to students using verb + preposition collocations in a way that "doesn't make sense in English," Dr. Robins, considers sentence length:

> **Dr. Robins**: I'm sorry, I'm giggling because it's like OK, so this last sentence is like 3.5 [lines] long and it's got this like *story* line...

Dr. Robins makes a connection between sentence length and reflective writing strategies, suggesting that the example in Table 4.11 may be indicative of students transitioning to the reflection component of their assignment, albeit ineffectively. Based on Dr. Robins' comment, sentence length may also speak to the degree to which students achieve clarity and conciseness in their writing. The idea of adding a story line to their executive summary is not only comical to Dr. Robins but also an indication of students' "language style" moving away from "checkbox-y" to "strange elaboration." What can further be observed in the student example is that students whose texts often have lengthy sentences demonstrate a lack of understanding of sentence boundaries and how to effectively write complex sentences. The example in Table 4.11 is from the second assignment, Net Zero Energy, and was one that Dr. Robins referred to as using a "story-line"; it was 3.5 lines of text in a paragraph. The textual example in Table 4.11 is bit

unclear and cumbersome. Students did not clearly separate sentences with the appropriate punctuation, resulting in a comma splice. The example also has two misspelled words (e.g., *give*, which should be *given*; *genera*, which should be *generate*). There is also a bit of redundancy that contributes to faculty assessing this particular section as ineffective. Spelling and grammar are not frequently discussed in the pedagogical materials; it is, however mentioned in the rubrics when addressing "professional communication," where students are expected to submit writing that is "free of grammatical or spelling mistakes and in a formal tone, appropriate for engineering school and workplace." The student example below in Table 4.11 was written by a group of four students with diverse language backgrounds. It is uncertain whether or not this particular sentence was written by an L1 student or an L2 student; however, Dr. Robins did make mention when the "voice" or "style" shifted to a "different" student. There was an assumption, at times, that these shifts represented L2 student writing.

Table 4.11 Mechanics, Grammar, Punctuation, & Syntax Interview Data & Student Example

Interview Data	Textual Examples
Dr. Rodriguez: "yea and I think that's what they do and I don't … like yea, like you sometimes you see, I remember I was reading something and I was like this phrase doesn't make sense, but it doesn't make sense because it's lacking a verb or it has two or three verbs in a row or it has a preposition or two prepositions that just don't go together and you can tell that it was someone trying to translate from their own language to [English] because you…yea… this structure just doesn't make sense in English."	For example, our house could use a house with a slightly shorter roof, which still has enough place to accommodate enough solar panels to fit the requirement of net zero energy usage, as finally that is the goal, and a very important one too, give the alarming rate at which the world is warming up due to the heavy amounts of carbon emissions by the coal boilers used to genera currently-used electricity.

Your work will be graded on completion of the following objectives:

- PA01: Identify strengths in problem solving/design approach.
- PA02: Identify limitations in the approach used.
- PC01: Use professional communication (written, visual, and oral), free of grammatical or spelling mistakes and in a formal tone, appropriate for engineering school and workplace.

Figure 4.12 Mechanics & Grammar: Pedagogical Rubric

4.3 Discussion: Effective Communication and First Year Engineering

The purpose of this chapter was to answer the following research question:

1. Based on faculty perceptions, what constitutes 'Effective Communication' in First Year Engineering?

To answer this question, I applied a genre analysis framework to discourse-based interviews and textual analysis of students' texts from the FYE problem statement corpus accompanied with pedagogical materials. Findings show that there are seven categories that impact faculty perceptions of effective communication:

1. Audience Awareness
2. Specificity of Content & Data
3. Organization, Structure, & Logical Flow
4. Reflective Writing Strategies
5. Vocabulary & Discipline-specific Meanings
6. Impact of Pedagogical Materials
7. Clarity & Conciseness
8. Genre Conventions & Formality
9. Mechanics, Grammar, Punctuation, & Syntax

Vocabulary & Discipline-specific Meanings (VDSM), with the most occurrences at 37%, appeared to interact with effective communication on multiple levels. For instance, when students were perceived as less effective in terms of Clarity & Conciseness, Organization, Structure & Logical Flow, Specificity of Content & Data, and Audience Awareness, VDSM was generally at the center of the conversation. Interestingly, Dr. Robins was the interviewee who engaged with VDSM the most, often reflecting on how problematic, and challenging, it is to request that first-year students be required to learn vocabulary that may not serve them beyond FYE. Much of Dr. Robins' resistance to discipline-specific language in this setting may be attributed to her multidisciplinary background and diverse teaching load, which requires her to move between various engineering disciplines and work with students with a wide variety of backgrounds (including both education and culture). Dr. Robins raises some unique observations and questions that align with ESP frameworks of teaching writing and vocabulary: understanding a text requires that writers and readers not only know the information contained within the text but are also able to critically evaluate and effectively use that knowledge (Johns & Dudley-Evans, 1980). All interviewee participants agree that they expect students, on some level, to evaluate the information in the pedagogical handouts, to internalize that information, and then write in such a way that demonstrates their growing understanding of procedural knowledge, conceptual knowledge, and writing knowledge. Unfortunately, both interview and textual analyses demonstrate that students are struggling with understanding and appropriately using vocabulary with discipline-specific meanings; students who demonstrate discipline-specific knowledge of vocabulary (e.g., *criteria, constraints, trade-offs, limitations, assumptions*, etc.) tend to be perceived as more effective. Additionally, students with an internalized understanding of the meaning variations of vocabulary are better able to write concise, clear texts that are

appropriate for their intended audiences. Chung and Nation (2004) argue that "technical vocabulary is part of a system of subject knowledge" (p. 252). Vocabulary with discipline-specific meanings as well as general meanings, thus, may directly impact students' development of genre knowledge and subject matter knowledge, two domains that Beaufort (2007) argues need to be acquired in order for students to evolve into expert writers.

The impact of students' lexical choices, and often inappropriate and inaccurate use of discipline-specific terms, on faculty perceptions of effective communication also supports my argument that linguistic knowledge is an additional domain that needs to be considered when unpacking academic genre conventions and the interconnected relationship(s) that exist across multiple domains of knowledge including, subject matter knowledge, discourse community knowledge, writing process knowledge, rhetorical knowledge, and genre knowledge; in other words, language knowledge, which includes lexical proficiency, needs to be accounted for in both research and pedagogy. Adopting ESP approaches to teaching, and research which focus on context-dependent vocabulary instruction, may allow FYE faculty to develop materials that support both L1 and L2 students' development of discipline-specific knowledge of vocabulary. For example, when considering a term such as "trade-off" it is essential to consider how students might encounter the term "trade-off" outside of the classroom and the previous schema that shapes their understanding of the discipline-specific meanings they encounter in the pedagogical materials. For instance, "trade-offs," as an everyday term, is often observed in political and economic contexts – a quick google search (a likely activity for students) does not generate any immediate engineering-specific uses. It might be worth asking students to note the differences between "trade-offs" when handling political policies versus criteria and constraints for a design project. As Dr. Reis described during her interview, vocabulary do not easily translate from

language to language; in Dr. Reis' experience, students whose first language is Spanish tend avoid terms like "trade-offs" and "iterations" because of the negative connotations associated with these terms in their L1. If students' linguistic knowledge of English is not adequately developed, they may have difficulties engaging with and making appropriately expected complex language choices. Students' lexical knowledge, as observed in this chapter, does in fact impact the quality, and effectiveness, of their writing (see Schoonen et al, 2011 for a discussion on the influence linguistic knowledge, metacognitive knowledge, and fluency on L2 writing). Crossley, Salsbury, McNaramara, and Jarvins (2011) explain that lexical proficiency, as an area of inquiry in second language studies, has demonstrated a strong relationship between L2 students' academic success and lexical knowledge (see Daller, van Hout, & Treffers-Daller, 2003), and L2 student's misuse and misunderstanding of vocabulary is one possible cause for ineffective communication (see Ellis, 1995).

Impact of Pedagogical Materials was another element of effective communication that was frequently broached during the interviews. All three FYE faculty agree that the pedagogical materials, at some level, may have a negative impact on how students are engaging with procedural knowledge, conceptual knowledge, and writing process knowledge. The Airplane Rodeo Assignment, as the first task with a problem statement, appears to be intended as a scaffolding tool, which explains why students are asked to "fill in the blanks" with appropriate content from supplementary materials. The genre-based formula appears to be helpful in providing the genre structure for how to engage with problems and solutions, and identifying the syntax and language appropriate and expected for each of these two spaces; unfortunately, it is unclear whether or not students are expected to rewrite, paraphrase, or synthesize the information or if copying and pasting content from supplementary pedagogical materials is an effective

strategy. On one hand, interview participants express a desire for students to engage with the information, to consider the gaps in the content provided to them from their clients, and to demonstrate their internalization all of this new knowledge by adapting the pedagogical materials and retelling the information in their own words; on the other hand, FYE faculty recognize that this might be a higher order skill that students have yet to have time to develop. The trade-off they make then, is focusing on the content students produce and looking beyond the language and communication errors that arise. FYE faculties interactions with and responses to students' writing likely speaks to their recognition that students are novice writers and not experts; as novice writers, students are engaged in "knowledge telling" rather than "knowledge transformation" (see Bereiter & Scardamalia, 1987). Yore, Hand, & Prain (2002) describe the process of knowledge telling as representing "recollections in printed symbol essentially unaltered" and knowledge transformation (or building) as "an act of learning where there is a dynamic between the content being addressed and the rhetorical requirements of the writing task" (p. 674). As first-years, students do not have an adequate level of discipline-specific knowledge (subject matter, genre, conceptual, procedural, etc.) to build new knowledge. The possible gap that arises is whether or not that pedagogical materials sufficiently guide students from "knowledge telling" to "knowledge transformation", where new, and critical, knowledges are internalized.

As students progress through the semester, the problems they are asked to engage with become more open-ended and ill-defined. For Dr. Reis, this negatively impacts students' ability to write effective problem statements. For Dr. Rodriguez, this is a scaffolding strategy that pushes students to critically apply the skills they have been developing throughout the semester. The Net Zero Energy Assignment and the Final Design Report are both assignments where

students are given less constraints for the problem than they encountered with the Airplane Rodeo Assignment. Students are provided with additional supplementary materials, like the "problem-scoping" handout, where they are guided towards identifying the content that is expected to be addressed in the executive summary, where the problem statement is, including additional audiences students are elicited to account for (e.g., clients, stakeholders, and users). What is observed with the predagogical materials is that as the problems become more open-ended, so do the structure and genre conventions of the text(s). The differences in structure and genre conventions between the first and second assignment, for example, leads to a meaningful amount of variation in the local and global choices students make – for some texts, the problem statement is not immediately identified in the introduction. In the Net Zero Assignment, students are often observed making similar ineffective structural choices that Conrad (2018) identified in her research; rather than moving clearly and sequentially from client, problem, and context to possible solutions and finally their preferred solution, students often place solution-specific information within the problem space.

As a recurrent rhetorical action (see Miller 1984), problem statements acquire and exhibit meaning and purpose that is unique to the FYE context. Faculty perceptions of effective communication are closely aligned with the genre conventions they expect students to learn and employ in their writing. The rhetorical structure of the typified genres in FYE (e.g., technical briefs and technical reports) highlights the social and intellectual activities that are valued in FYE, particularly with the emphasis on problems, context, and clients. As an introductory course, students are learning how to first engage with problems, contexts, and clients before engaging with objects, or solutions; while technical briefs and technical reports may overall focus on the objects and the design process, the problem statement provides a scale for students

and faculty to assess the validity and relevance of the preferred, and final, solution provided to the client. In some ways, it may be argued that the problem carries more weight and significance than the solution; if students fail to understand the problem, the client's needs, and the context of the problem, their solutions and the subsequent objects they design will fail to address the problem. The gap that faculty notice (and what I have noticed in my analyses) is that students tend to focus more on the solution rather than intentionally dwelling with and unpacking the problem. Prematurely addressing a specific solution in the problem space reveals a writer as a novice, or outsider. The pedagogical materials do make distinctions between problem spaces and solution spaces by providing students with the discourse structures and discourse organization that faculty expect students to follow; however, it may not be enough to provide students will templates that encourage "knowledge telling." What may be of particular benefit to FYE is considering how providing students with model genres where problem statements have been effectively written may impact students' progress towards knowledge building, and their overall writing process.

As an outsider, the genre conventions for problem statements are not so straightforward. The rhetorical practices that problem statements fulfill appear to be linked to problem-based and project-based learning, especially because students collaboratively write the majority of their assignments. As a recurrent rhetorical move in all three assignments, and what I assume to be other assignments in FYE, the genre conventions of problem statements remain rather static throughout – from the perspective of the faculty anyways. However, based on students' writing and the pedagogical materials, the genre conventions for problem statements, or the typified genres they live in, are rather quite fluid. For the Airplane Rodeo Assignment, the expected conventions for problem statements are that they are the first move in the problem space and

should include at least three steps: (1) direct reference to a client, (2) an identification of criteria, and (3) an identification of constraints. Identification of assumptions, limitations, and trade-offs appear negotiable for the faculty, but ultimately occur in the solution space. The conventions for the second two assignments, The Net Zero Assignment and The Final Design Report, become a bit more nebulous. How students communicate who the client is, what their needs are, what the problem is, and the criteria and constraints becomes more fluid not only between assignments, but also between students' texts. While the pedagogical materials may suggest a format and structure, students are ultimately able to deviate from the prescribed genre conventions as long as the conceptual and procedural knowledge they have acquired are adequately and accurately communicated. However, faculty generally agreed that those students who followed the conventions as outlined in the pedagogical materials were perceived as more communicatively effective; in this respect, genre knowledge appears to interact with perceptions of effective communication and influences how faculty assess students' development of discipline-specific knowledge.

Whether or not a problem statement is considered to be effectively communicated is directly linked to students demonstrating the development of conceptual and procedural knowledge specific to engineering design. As I mentioned earlier, students' appropriate and accurate use of vocabulary is one way that faculty assess students' knowledge development; recurrent language chunks, and how well students do, or do not, use the formulaic language in the pedagogical materials, thus becomes another marker for effective communication.

CHAPTER 5. FORMULAIC LANGUAGE & GENERIC CONVENTIONS

5.1 Introduction

In chapter 4, I provided the data analysis and results for FYE instructors' perceptions of effective communication using primarily qualitative methods: textual analysis of students' texts and the pedagogical materials, and discourse-based interviews. For this chapter, I address the following research questions using a mixed-methods approach:

1. What are the expected rhetorical moves and steps for problem statements and the immediately surrounding text?
2. What formulaic language represent the rhetorical moves and steps associated with problem statements?
3. Do students use the formulaic language from the pedagogical materials across all three assignments?

I begin this chapter revisiting my methods for analyzing the moves and steps of problem statements; specifically, I explain why the majority of my analysis focused on the first assignment, The Airplane Rodeo. I first provide an example of the Airplane Rodeo template with a student example, highlighting where the language between the texts are identical; I also provide an example of the n-grams identified in the corpus for the Airplane Rodeo Assignment. In chapter 4, section 4.2.1, I defined the terms *problem space* and *solution space*, as I understand them based on the interview data; in this chapter, I provide examples of how the moves and steps identified interact with these two spaces. As a reminder, the terms *problem space* and *solution space* are indicators of two distinct moves observed in the data; a *space* refers to a specific area of a genre type that contains a rhetorical move: identifying problems and identifying solutions. Problem statements, as a rhetorical move, are expected to occur in the problem space. Following

the move-step analysis, I provide data for the n-grams across all three assignments with the rhetorical functions they perform. Finally, I discuss the results in relation to the interview data in chapter 4 and the potential benefits of applying an ESP framework and a corpus-based approach to teaching discipline-specific writing in FYE.

5.2 Move-Step Analysis of Problem Statements: Identifying Expected Moves and Steps in Students' Texts

Understanding the expected rhetorical steps needed to successfully write a problem statement was an iterative quantitative-qualitative process in which I (1) identified the most frequent 3- and 6-word n-grams for each assignment, (2) qualitatively analyzed students' written assignments, (3) qualitatively analyzed the pedagogical materials, and (4) conducted discourse-based interviews with faculty in FYE. While I did analyze and code n-grams for rhetorical function and use of problem statements across all three assignments in the corpus, I focused on the first assignment, the Airplane Rodeo, when analyzing the expected rhetorical steps of problem statements to establish a baseline. I made this decision because the Airplane Rodeo is where students are introduced to the concept of and taught to write problem statements in a more constrained and scaffolded manner, leading to less variation in how students approach and write problem statements. Figure 5.1 provides an example of a pedagogical artifact for the first assignment, the Airplane Rodeo, with a student example. The pedagogical artifact is presented as is, meaning I did not make any changes to font, color, or content. Students are given this template and asked to fill in the appropriate information, and as I have observed in chapter 4, there are inconsistencies with faculty expectations of whether students should maintain the structure provided to them or recreate it in their own words. For the student example, I highlight

in green where students filled in the "buckets[6]" of information to match the green font that instructors provided in the pedagogical materials. Black font, then, represents the structure and language provided to students. As this first example shows, students did not take any creative liberties, and instead kept the exact structure and syntax provided to them.

a) Pedagogical Artifact

2 PAGES ONLY! Remove this text box!
Replace green text with your words and save as black text!
Create technical brief in PARAGRAPH FORMAT!
Steps should be numbered

To: Amelia Wright, TCAA
From: Section # Team #
Subject: Procedure for (what)
Date: (date)

The client, (who), requires a protocol that provides (this function(s)). In each of the two categories of Most Accurate and Best Floater, the criteria for success of this (deliverable) are (fill in Criteria for Success here). The constraints are (fill in Constraints).

The procedure is designed to (fill in overarching description of what procedure is designed to do). The key features of the math model are (fill in features).

The assumptions are (the conditions under which it is appropriate to use your deliverable). The limitations of our procedure are (fill in and explain limitations). Trade-offs that were made in order to achieve an attainable solution include (fill in and explain any trade-offs).

The **Most Accurate Award** will be given to the plane that (identify math model: what constitutes success, and define 'most' and 'accurate'). The winner of this award will be determined by:

1. (type clear steps; include any assumptions and/or rationale associated with step; include sample

[6] "Buckets" is the term that Dr. Robins uses to refer to the blank spaces in pedagogical materials that students fill in with information from supplementary materials.

b) Student Example

To: Amelia Wright, TCAA
From:
Subject: Procedure for Scoring
Date:

The client, Twin City Aviation Association, requires a protocol that provides an effective scoring system that is fair and objective. In each of the two categories of Most Accurate and Best Floater, the criteria for success in this scoring system is getting the maximum amount of points to determine a winner for each TCAA award. The constraints are the judges ability to effectively use the mathematical systems and to judge the planes based on the specific guidelines.

The procedure is designed to accurately score the planes based on simple data and award the winner on concrete evidence and not biased opinions. The key features of the math model are the expressions used to calculate the winner in the best floater award and the most accurate award.

The assumptions are that these guidelines can be used for all planes in the competition and that the winner will be determined in a fair manner. The limitation of our procedure is the fact that we weren't physically able to observe the data given; thus, working only with data that was provided. Trade-offs that were made in order to achieve an attainable solution include sacrificing a small percentage of accuracy for a simpler, more efficient, and fair way of scoring.

The **Most Accurate Award** will be given to the plane that landed the closest to the target and took the shortest route to get there. The winner of this award will be

Figure 5.1 Airplane Rodeo Assignment Pedagogical Material & Student Example

In addition to qualitatively examining students' examples alongside pedagogical materials, I quantitatively analyzed instances of the most frequent 6-word n-grams using a corpus software tool, AntConc (Anthony, 2019), for all three assignments. As Table 5.1 shows, the first 33 instances of 6-word n-grams for the first assignment, the Airplane Rodeo, all had frequencies over 100. All 33 n-grams, including number 14, *the two catergories of most accurate*, where a spelling error occurs, can be linked back to the pedagogical materials for the Airplane Rodeo Assignment. In other words, the most frequent instances of formulaic language in students' writing are directly related to the language that appears in the pedagogical artifact for the Airplane Rodeo Assignment. As I explained in chapter 3, identifying the most frequent n-grams in each of the sub-corpora allowed for a better understanding of the language that students used

and the relationship of their language choices with the pedagogical materials. It was largely because of the high frequencies of these n-grams that I began investigating the pedagogical materials. In section 5.3, I provide results from the qualitative coding of the most frequently occurring n-grams for their rhetorical function and use as it relates to the problem statement. For now, it is important to note that all 33 n-grams from students' texts for the Airplane Rodeo Assignment in Table 5.1 can be attributed to what I first identified as expected rhetorical steps of problem statements.

Table 5.1 Airplane Rodeo N-grams

Frequency	Range	N-gram
343	326	most accurate and best floater the
331	313	of most accurate and best floater
330	330	the criteria for success of this
322	322	and best floater the criteria for
321	321	accurate and best the criteria
320	320	best floater the criteria for success
317	311	categories of most accurate and best
316	315	in each of the two categories
316	316	in order to achieve an attainable
316	316	order to achieve an attainable solution
313	313	made in order to achieve an
311	311	floater the criteria for success of
308	307	two categories of most accurate and
307	307	the two catergories of most accurate
305	305	each of the two categories of
305	305	of the two categories of most
303	303	to achieve an attainable solution include
303	303	were made in order to achieve

Table 5.1 continued

Frequency	Range	N-gram
301	301	that were made in order to
300	300	offs that were made in order
300	300	trade offs that were made in
292	292	the limitations of our procedure are
262	261	the key features of the math
254	253	key features of the math model
243	242	features of the math model are
174	174	requires a protocol that provides a
135	135	twin cities aviation association requires a
133	133	limitations of our procedure are that
114	114	wright requires a protocol that provides
113	113	the client amelia wright requires a

In my initial analysis of the pedagogical materials and students' texts – before the discourse-based interviews – I noted seven rhetorical steps that consistently appeared within what I assumed was the problem statement. These include the following:

1. a direct reference to a client;
2. an identification of the client's needs;
3. an identification of criteria;
4. an identification of constraints;
5. an elaboration on criteria and constraints;
6. an identification of assumptions;
7. an identification of limitations; and
8. an identification of trade-offs.

Adapting Swales (1990) move-step analysis framework for article introductions, I mapped the steps to the specific places in students' texts. As the first rhetorical move in of a genre, the problem statement establishes who the client is, the problem the client is requesting assistance with, and the criteria and constraints the engineer needs to consider and negotiate as they develop plausible solutions. The problem statement essentially acts as the compass for the entire document (whether that be a technical memo, a technical brief, or design report), including the development of a final solution. Observations of students' texts for The Airplane Rodeo Assignment, demonstrate that steps 1 through 5 follow a designated order while steps 6 through 8 may vary in the order they appear. Figure 5.2 is an example of a problem statement from the Airplane Rodeo Assignment that I extracted from the corpus for my interview with Dr. Robins mapped with the expected steps to achieve the problem statement move.

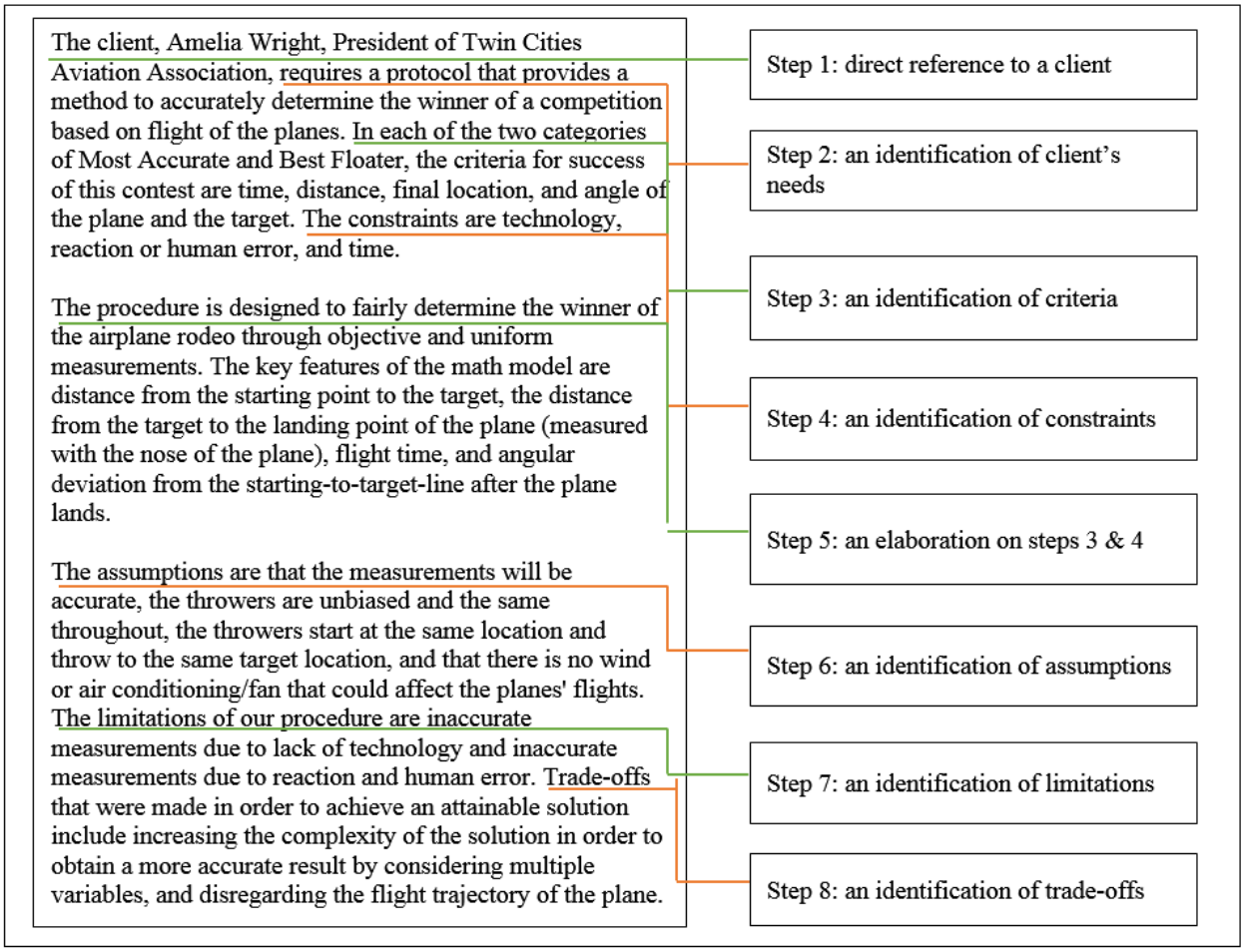

Figure 5.2 Move/Step Analysis of Problem Statement for Airplane Rodeo Assignment

To triangulate my findings, I asked interview participants to explain and define problem statements from their perspective as faculty and as engineers.

> **Dr. Rodriguez:** A problem statement is a description of the project that the student is going to work on and it includes what's *the problem* or *the need* or *the focus of the project* or you know like the need that students would like to fulfill by conducting that project or what are they focusing on or what's the problem that they will try to solve; it will include a description of why that problem is important to solve or who asked them to do that or why are they doing it and a little bit of background to understand that context where the problem is being

> solved, that's part of the why it's important and it will also have some kind of things that you will look for in a solution, not a solution, but *characteristics of a good solution* that what we call the kind of design criteria and it will also contain any restrictions [constraints] that the student will have while doing that project so either if it's a budget or time or any other constraint that they will have and for me that problem statement is kind of the take of the student on what are they doing in this project; it's like in their own words, their own explanation.

According to Dr. Rodriguez, the problem statement is multi-functional and includes a statement indicating the problem, the need, or the focus of the project, a description that contextualizes why the problem is important to solve, who asked them to solve the problem, and characteristics of a good solution, or design criteria and constraints. Dr. Rodriguez' expectations for the genre conventions matches what is outlined in the Rodeo Assignment Template; albeit the first assignment appears to leave little room for students to contextualize why the problem is important, focusing instead on identifying the purpose of the procedure that students are designing. The focus here aligns with Winsor's observation of engineering being object-oriented as the assignments throughout the course appear to be project-based with the added component of students being expected to critically dwell with problems. The genre conventions in place then, do reflect these expectations – the potential problem that arises is in how students do (or do not) conceptualize and differentiate between problems and solutions in their writing. Dr. Rodriguez also states her desire to see students internalize the information in the pedagogical materials and then write the problem statement in their own words; she later indicates that the internalization of information is a more advanced skill that she does not expect to see right away, but rather something that students are guided towards.

Dr. Reis' has a similar definition for a problem statement; her explanation below is from her interaction with an example student text from the Net Zero Energy Assignment, the second of the three projects:

> **Dr. Reis:** I would say [the] problem statement basically *explains what the problem* is …so if you look at it from that perspective, this is the context, it provides the context or who, client or user…what the client needs…a building…has to have four separate rooms, it needs to net zero energy, it needs to use solar power, it needs to be comfortable, and there's a limited budget. *These are problem specifications*…

Dr. Reis states, however, that *criteria* and *constraints* are "problem specifications" whereas Dr. Rodriguez calls them "characteristics of a good solution." How instructors articulate the differences between problems and solutions may certainly impact how students approach discipline-specific genres and may also account for the difficulties students have in how and when to disambiguate problems from solutions in their writing.

In addition to asking faculty to define problem statements, I asked each to confirm whether my move-step analysis for problem statements was accurate in my initial findings. When I asked Dr. Robins about steps 1-4, she confirmed that these were expected rhetorical steps for a problem statement and indicated that some variation in how students perform these steps may be present. Dr. Robins also elaborated on the tricky nature of particular words like *criteria* and *constraints*: "[criteria and constraints are] sort of like a particular language or jargon that we use – same with 'needs' and so they're a little bit more explicit about that one so those should both be there." For steps addressing limitations, assumptions, and trade-offs, Dr. Robins said that these terms are typically "tagged on to solutions," but that students might exchange

“scope” for limitations if asked to address these in the problem statement, and that “assumptions” is a more advanced term that she would not expect with first year students, because “you’re sort of bringing them into a culture with all of its language and it just might be like there’s a lot of new language” and “assumptions” may not immediately benefit students. While Dr. Robins may find these last set of terms, associated with solutions, as potential pitfalls for students, the pedagogical materials do explicitly ask students to use these words. Interview data suggests that the only steps I identified in my initial findings that occur in the problem statement are the first four:

1. a direct reference to a client;
2. an identification of the client’s needs;
3. an identification of criteria;
4. an identification of constraints; and

Step 5, as it is represented in the Airplane Rodeo Assignment, appears to be a bridge between the first four and the last three; however, it does occur in the solution space. Returning to the example in Figure 5.2 then, figure 5.3 highlights where the steps occur in relation to the rhetorical move and spaces of the genre within the introduction of the text.

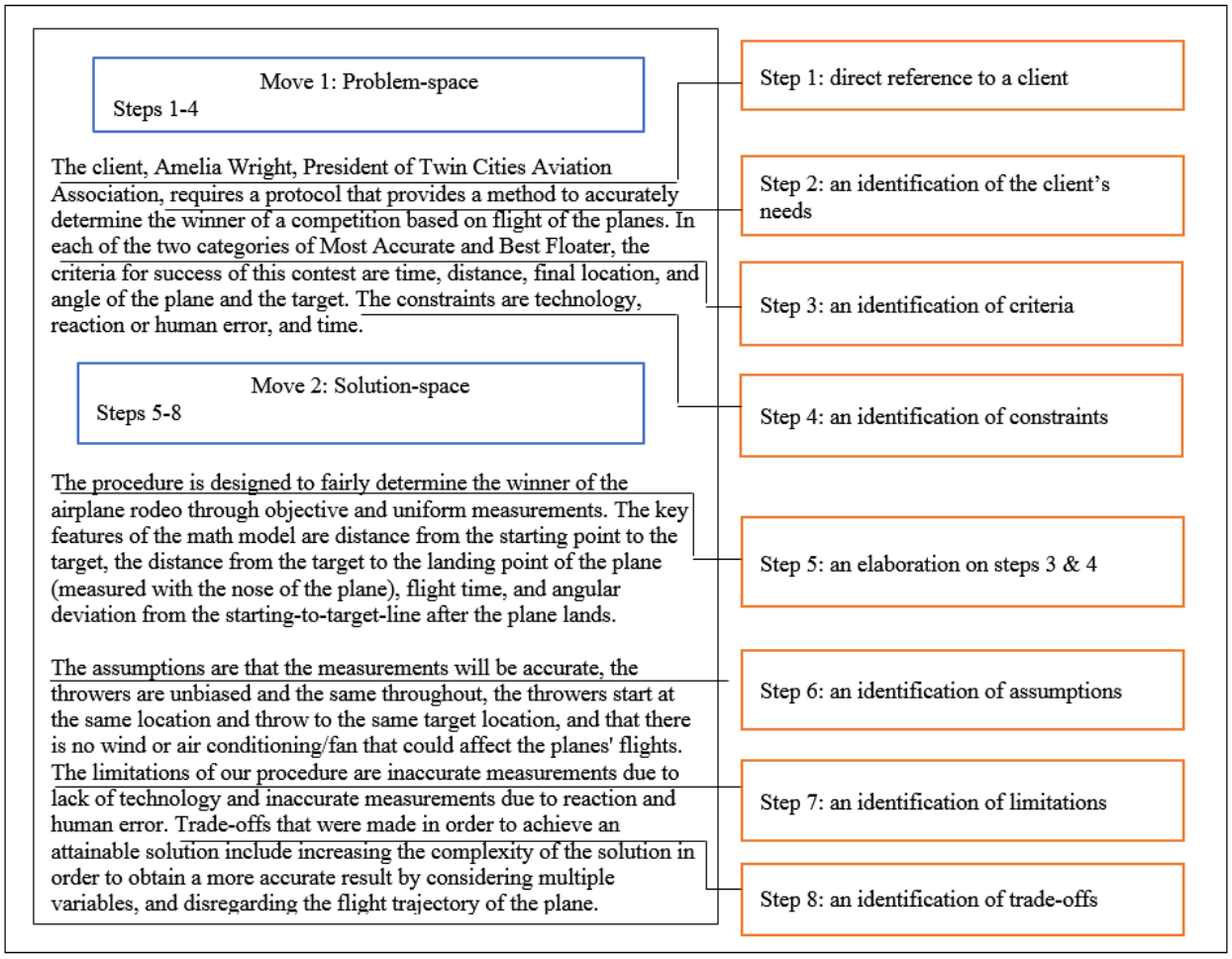

Figure 5.3 Move/Step Analysis of Problem Statement for Airplane Rodeo Assignment

Because the first assignment was the baseline for the expectations of effective writing, I decided to also compare how students approached writing problem statements, and solutions, in their subsequent assignments, the Net Zero Energy Assignment and the Final Assignment. Figures 5.4 and 5.5 are examples of writing from these two assignments from the same group of students in the example in Figures 5.2 and 5.3. For this assignment, in this specific section of ENGR 131, students were provided a suggested outline to follow that ensured students met the requirements for the document. While some students do take creative liberties, this particular group opted to follow the format provided, as they did in the first assignment. What is immediately noticeable

are the signposts that Dr. Robins prefers to see in students' writing.[7] Additionally, the problem statement in the example from the Net Zero Energy Assignment is a single sentence that reads more as a mission for the group than a statement for outside readers (e.g., clients, users, and stakeholders). In this one sentence, however, students perform two of the key steps: *identification of the client* and *identification of the client's needs*. The writers also address cost, efficiency, and usefulness of solar panels – language that is often ascribed to criteria and constraints, indicating that steps 3 and 4 are embedded within this sentence, though not explicitly stated as the interview participants anticipate. In addition to identifying the problem in this sentence, the writers also explicitly state their solution: solar panels. Based on interview data, this move, weaving in and out of the problem-space and the solution-space without any clear boundaries, is not an effective strategy. I note this because, according the interviews, students should not provide solutions in their problem statement; students are asked to engage with the problem from the client's perspective by providing the problem specifications, or characteristics of a good solution, with the associated data. In this particular example, however, students are approaching the problem with a solution already in mind. Conversely, interview data also suggests that there is no minimum or maximum expected length for a problem statement. A single sentence *can* be effective if done appropriately while multiple sentences can also be perceived as ineffective if not clear and concise. In this specific example (Figure 5.4), the placement of the problem statement is at the beginning of the document as part of an Executive Summary. Immediately following the problem statement is the section *Information Gathering & Assumptions Made*, where students make a clearer move towards examining and justifying the solution they recommend to their client.

[7] These are not texts from a class Dr. Robins taught.

Recommendation to the Mayor of Indianapolis

I. Problem Statement

Help the mayor of Indianapolis to find ways to reduce the amount of CO2 emissions within Indianapolis by using solar panels and determine if this would be a cost efficient and useful change.

II. Information Gathering & Assumptions Made

Assumptions:
We are assuming that a solar panel emits 50 g of CO2 per k Wh, obtained from mother nature network website cited below. We also assume that we aren't going to incorporate the fact that there is C02 emission from installation and transportation.

Sentence 1:
1.2. identification of client
1.3. statement of problem (client's needs)
1.4. statement of solution
1.5. statement of criteria and constraints

Figure 5.4 Student Example from The Net Zero Energy Assignment

In the third example (see Figure 5.5), the Final Design Project, the executive summary provides a snapshot of the entire document, which often exceeds eight pages, and the problem statement is expected to occur in the beginning of the executive summary as an introduction to the context, the client, and the problem. Unlike in their second example (see Figure 5.4), the problem statement is not a single sentence, and the entire move for the problem statement is three sentences long. Interestingly, the students do not use expected language for identifying the client, the need, the criteria, or the constraints; instead, students provide a broader contextualization for the problem, including identifying the users, which, as noted earlier, is a step expected when discussing the solution. As the students begin to make the third and fourth steps, identifying criteria and identifying constraints, they choose to continue refraining from using discipline-specific language and instead list the absolutes that need to be considered when providing a solution (e.g., eco-friend, warm, recyclable). The writers do not begin using discipline-specific language until they move into the solution-space where criteria and constraints are stated more explicitly and several times; this repetitiousness, in addition to the

lack of specificity of content and applicable data, impedes the effectiveness of students' written communication.

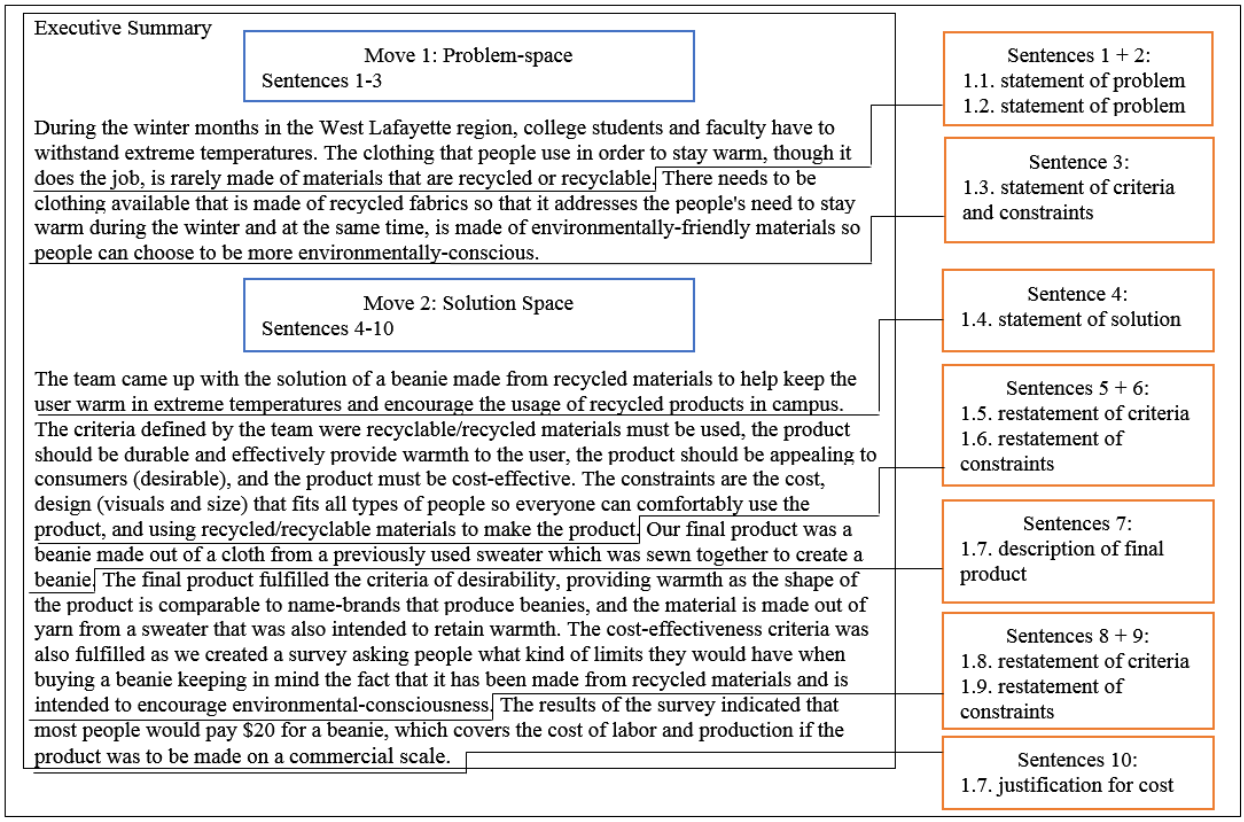

Figure 5.5 Move/Step Analysis for Final Design Project

While there appears to be clear expectations from the FYE faculty for how students should approach problem statements and how students should describe their suggested solutions, several of the texts I analyzed in the corpus, including the examples above, often fail to explicitly address the four expected steps for problem statements: (1) identification of client, (2) identification of client's needs, (3) identification of criteria, (4) identification of constraints. Rather, it appears that students tend to approach problems with solutions in mind, which is a possible indicator that students have not adequately grasped the genre conventions expected in

FYE – particularly as it relates to understanding the differences between the problem space and the solution space.

5.3 Formulaic Language and Problem Statements

5.3.1 Airplane Rodeo Assignment

In this section I provide the results for the formulaic language coded for the Airplane Rodeo Assignment, students first assignment with a problem statement. After overlap within the top 50 most frequent instances of formulaic language were identified, I coded 15% of the concordance lines extracted from the corpus for the 10 n-grams in Table 5.2 for the rhetorical functions (e.g., the steps each n-gram performed). Table 5.2 provides the raw frequencies for each n-gram; because the frequencies were rather high, particularly those that were above 100, a minimum cut-off point was not necessary. However, all instances coded did have a frequency above 40, which is typically the minimum frequency established in research.

Table 5.2 N-grams Coded for Rhetorical Functions

Frequency	Range	N-gram
343	326	most accurate and best floater the
330	330	the criteria for success of this
303	303	to achieve an attainable solution include
292	292	the limitations of our procedure are
174	174	requires a protocol that provides a
135	135	twin cities aviation association requires a
133	133	limitations of our procedure are that
71	71	criteria for success of this procedure
65	65	limitations of our procedure are the
57	57	the airplane rodeo information we assumed

Figure 5.6 shows n-gram 1, *most accurate and best floater the*. Of the 343 occurrences for this n-gram, 15% (n=52) of the lines were coded; 96% (n=50) of those instances were Identification of Criteria (IC), and two of those instances were Purpose of Client's Needs (PNC). All instances of IC directly followed Identification of Client's Needs (CN), as expected based on the pedagogical materials. All instances coded occurred in the problem-space as a rhetorical step in the problem statement. Additionally, all instances of n-gram 1 were word-for-word based on the pedagogical materials; in other words, students did not revise or edit the language or grammatical structure before submitting their final drafts. Below are two examples of CN from the corpus for n-gram 1:

- *In each of the two categories of <u>Most Accurate and Best Floater, the</u> criteria for success of this judging system are that the method is impartial and fair, should leave little room for interpretation and must be clear in its description of point allocation.*
- *In each of the two categories of <u>Most Accurate and Best Floater, the</u> criteria for success of the contest winner rules are to have a fair contest with accurate data results for each team.*

What is further noted in these observations is that n-gram 1 occurs with an introductory clause for criteria. Lexical variation in student's writing only occurs after "success" in which students being to conceptualize and describe criteria for their math models. It is arguable whether the criteria that students provide are clear, measurable, and accurate.

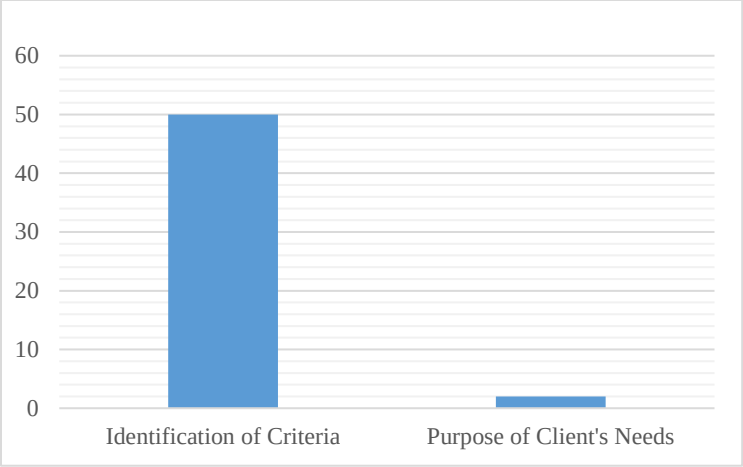

Figure 5.6 N-gram 1 most accurate and best floater the

Figure 5.7 shows n-gram 3, *the criteria for success of this*. Of the 330 concordance lines extracted from the corpus, 15% (n=50) were coded; 100% (n=50) of those instances were IC; however, 10% (n=5) of coded data were observed as Inaccurate Use of Term (IUT) because students gave vague and inaccurate descriptions for *criteria*. All instances coded occurred in the problem-space as a rhetorical step in the problem statement. N-gram 3, upon first observation, may be considered overlap with n-gram 1; however, not all instances for n-gram 3 are connected with n-gram 1; this is also one of the few n-grams that explicitly uses the expected vocabulary (e.g., *criteria*). Therefore, it is essential to qualitatively observe the degree to which students accurately use discipline-specific vocabulary. Below are examples of both IC and IUT.

Example IUT:

- *<u>The criteria for success of this</u> procedure are to determine the winners of these awards.*

Example IC:

- *In each of the two categories of Most Accurate and Best Floater, <u>the criteria for success of this</u> model are fairness, replicability and applicability.*

In the first two examples, students fail to accurately and clearly provide criteria that are being considered for their math model. For example, "…criteria are to determine the winners of these awards" would better be described as the goal of the project and not the criteria for their math models. While "fairly" and "simply" may be considered vague language, it is language that comes from the pedagogical materials.

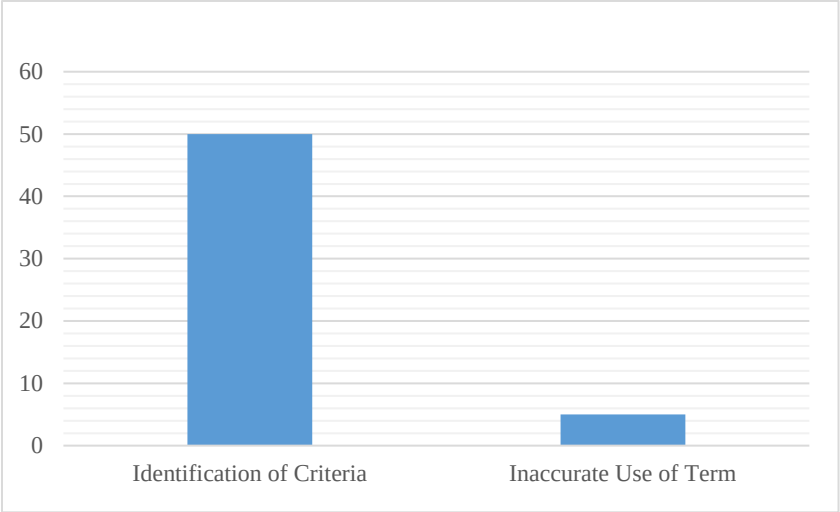

Figure 5.7 N-gram 3 the criteria for success of this

Figure 5.8 shows n-gram 17, *to achieve an attainable solution include*. Of the 303 concordance lines extracted from the corpus 15% (n=45) were coded; 77.77% (n=35) of those instances were coded as Identification of Trade-offs (ITO), 22.23% (n=7) were coded as IUT. All instances occurred in the solution-space. All ITO and IUT coded concordance lines included the use of passive constructions.

Example ITO:

- *Trade-offs that were made in order <u>to achieve an attainable solution include</u> a more simplified floater equation for the sake of simplicity for the judges.*

Example IUT:

- *Limitations and/or trade-offs that were made in order <u>to achieve an attainable solution include</u> the assumption that all three pilots were consistent in there throws for all three planes and that wind was negligible during the competition.*

The example for ITO highlight language that is commonly used with trade-offs, including *compromise* and *for the sake of*. For the IUT example, students focused on assumptions rather than limitations or trade-offs, making it an inaccurate use of a discipline-specific term

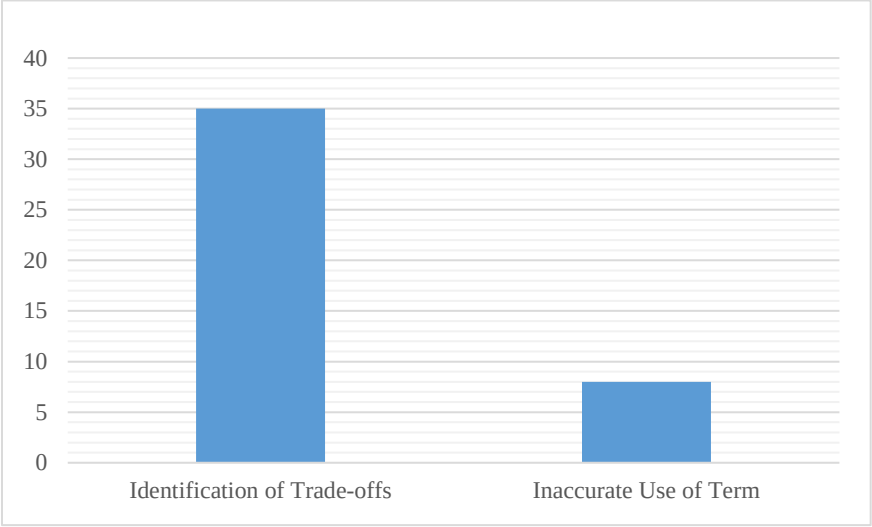

Figure 5.8 N-gram 17 to achieve an attainable solution include

Figure 5.9 shows n-gram 22, *the limitations of our procedure are*. Of the 292 concordance lines extracted from the corpus 15% (n=41) were coded; 85.36% (n=35) of those instances were coded as Identification of Limitations (IL), 14.29 % (n=5) were coded as IUT, and 2.4% (n=1) were coded as NA (students did not complete the assignment). All instances occurred in the solution-space. All IL and IUT instances included the use of possessive adjective, *our*, as markers of a solution.

Example IL:

- *<u>The limitations of our procedure are</u> that the model will only function if times, angles, and distances are all measured accurately.*

Example IUT:

- *<u>The limitations of our procedure are</u> the data collection methods at your disposal, which mirror the data you provided us.*

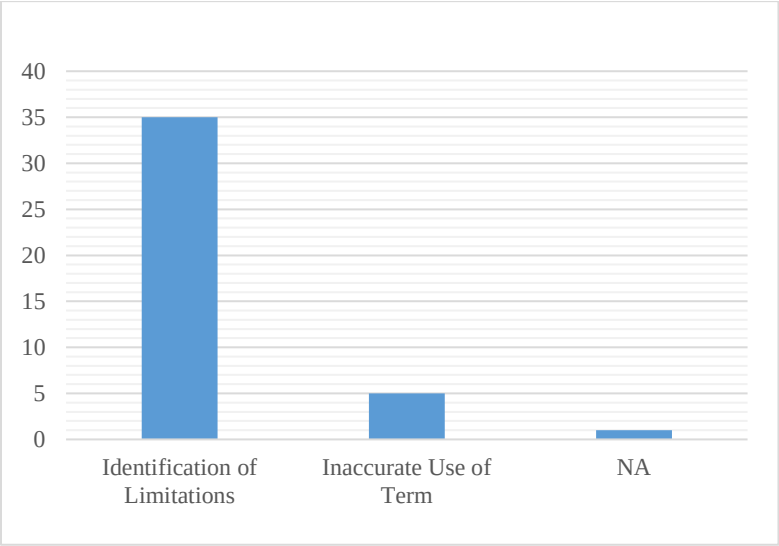

Figure 5.9 N-gram 22 the limitations of our procedure are

Figure 5.10 shows n-gram 26, *requires a protocol that provides*. Of the 174 concordance lines extracted from the corpus 15% (n=26) were coded; 100% of those instances were coded as CN All instances occurred in the problem-space as a rhetorical step in the problem statement, following CR. All instances had some variation of *model*, *method*, *procedure*, *evaluation*, *approach*, *and judging system* and the majority of instances included the use of evaluative adjectives: *fair*, *impartial*, *repeatable*, *consistent*, *simple*, and *standardized*. Additionally, all coded concordance lines included various types of *that*-clauses.

Example CN

- *The client, Amelia Wright, requires a protocol that provides a fair procedure using a mathematical model that will allow judges to determine the winners of awards in the Airplane Rodeo Challenge.*
- *The client, Amelia Wright, requires a protocol that provides a standardized judging template for judging. In each of the two categories of Most Accurate and Best Floater, the criteria for success of this template are most accurate and longest float.*

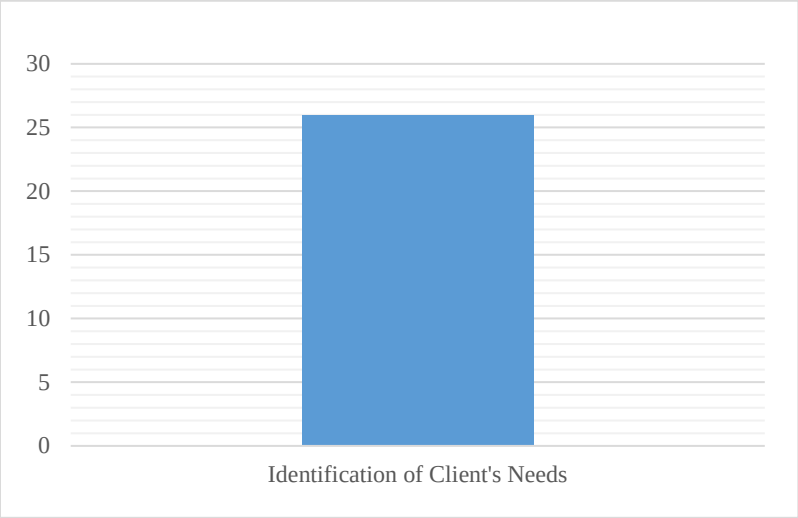

Figure 5.10 N-gram 26 requires a protocol that provides

Figure 5.11 shows n-gram 27, *twin cities aviation association requires a*. Of the 135 concordance lines extracted from the corpus 15% (n=20) were coded; 100% of those instances were coded as CR. All instances occurred in the problem-space as a rhetorical step in the problem statement, followed by CN. Vocabulary that students used following *requires a* include: procedure, protocol, solution, and system. Interestingly, all instances for n-gram 27 were appositives and noun-phrase + verb (np+v) constructions. While n-gram 27 may appear to be an overlap with n-gram 26, the two n-grams perform different rhetorical functions.

Below are two examples of n-gram 27:

- *The client, Twin Cities Aviation Association, requires a procedure to find the "Accuracy Award" for the most accurate plane and the "Floating Award" for the plane judged to be the best floater.*
- *The client, Organizers of a contest from Twin Cities Aviation Association, requires a protocol that provides a solution to finding an accurate analytical way of scoring a balsa planes' accuracy and floating time.*

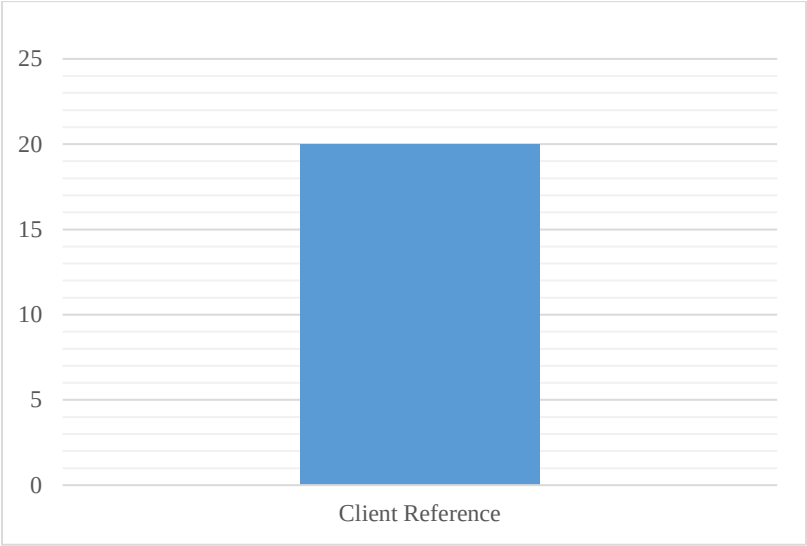

Figure 5.11 N-gram 27 twin cities aviation association requires a

Figure 5.12 shows n-gram 28, *limitations of our procedure are that*. Of the 133 concordance lines extracted from the corpus 15% (n=20) were coded; 85% (n=17) of the instances were coded as IL and 15% (n=3) were coded as IUT. Of the 85% IL steps, 82.4% (n=14) clearly followed the IA rhetorical step. All instances coded for n-gram 28 occurred in the solution-space and included the use of the possessive adjective, *our*. Interestingly, all coded instances were followed by various types of *that*-clauses. Below are example concordance lines for IL and IUT:

Example IL:

- *The limitations of our procedure are that the floater score only relies on total displacement, and not the total distance. This means that if a plane has a curvy path, our equation does not take into effect the total distance the plane traveled.*

Example IUT:

- *The limitations of our procedure are that is must be easily understood by both judges and contestants.*

The example IUT code was determined to be an inaccurate use of the term *limitations* because the information that follows appears to align more closely with criteria and constraints and students do not provide information about how, and by what, their models are limited.

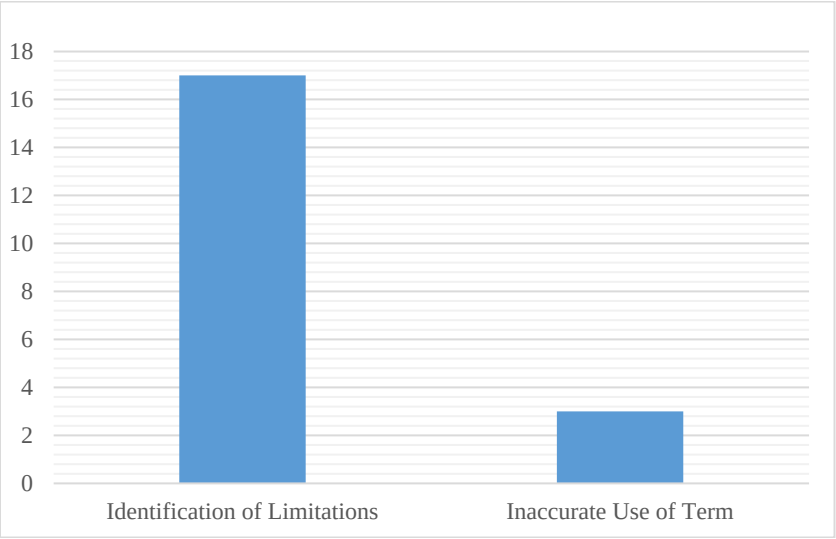

Figure 5.12 N-gram 28 limitations of our procedure are that

Figure 5.13 shows n-gram 41 *criteria for success of this procedure*. Of the 71 concordance lines extracted from the corpus 15% (n=11) were coded; 100% of the instances were coded as IC. All instances coded for n-gram 41 occurred in the problem-space, following CN; however, it appears that the majority of the instances coded (n=7) fail to provide measurable criteria. Interestingly,

students do not revise the syntax of the pedagogical materials for subject-verb agreement and often maintain the plural form, criteria, even they provide only one criterion. Below are two example concordance lines extracted from the corpus:

- *The criteria for success of this procedure are to create a mathematical model that will determine the winner of the awards of most accurate and best glider.*
- *The criteria for success of this procedure are best floater and most accurate airplane.*

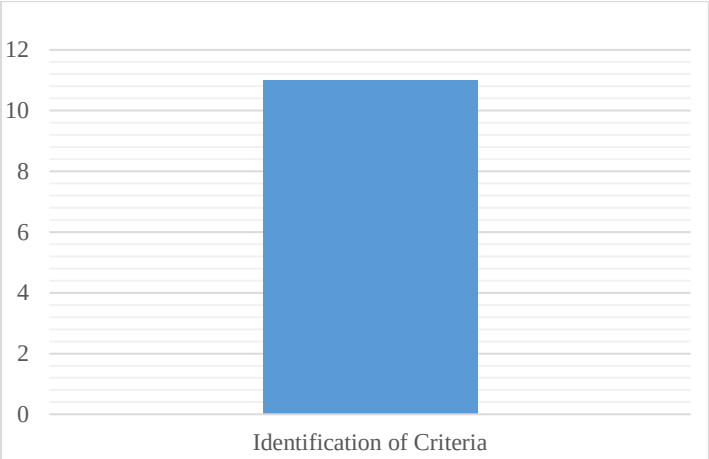

Figure 5.13 N-gram 41 criteria for the success of this procedure

Figure 5.14 shows n-gram 42 *limitations of our procedure are the*. Of the 65 concordance lines extracted from the corpus 15% (n=10) were coded; 100% of the instances were coded as IL. All instances coded for n-gram 42 occurred in the solution-space. Interestingly, like n-gram 41, students did not revise the syntax of the pedagogical materials for subject-verb agreement. Below are two example concordance lines extracted from the corpus:

- *The limitations of our procedure are the size of the space the competition is taking place.*
- *The limitations of our procedure are the influence of environmental factors such as wind has not been taken into consideration, so, the competition must be held in an indoor area.*

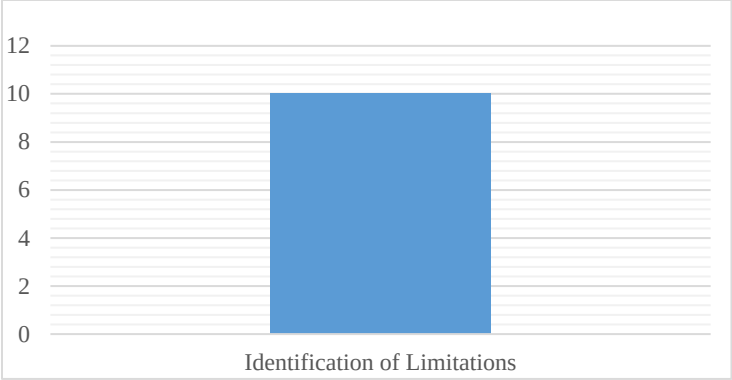

Figure 5.14 N-gram 42 limitations of our procedure are the

Figure 5.15 shows n-gram 49 *the airplane rodeo information we assumed*. Of the 57 concordance lines extracted from the corpus 15% (n=8) were coded; 100% of the instances were coded as IA. All instances coded for n-gram 41 occurred in the solution-space, following IC2 and directly proceeded by IL or ITO. Additionally, all instances coded included the use of the plural pronoun, *we*.

Example IA

- *Based on <u>the airplane rodeo information, we assumed</u> that the judges will know how to use our model, the divisions of best floater and most accurate are not changed, new judging criteria are not added, and our notion of fairness is shared by the judged.*
- *Based on <u>the airplane rodeo information, we assumed</u> that unbiased volunteers in the competition took the measurements for each plane including total distance, flight time, distance from target, and angle from target.*

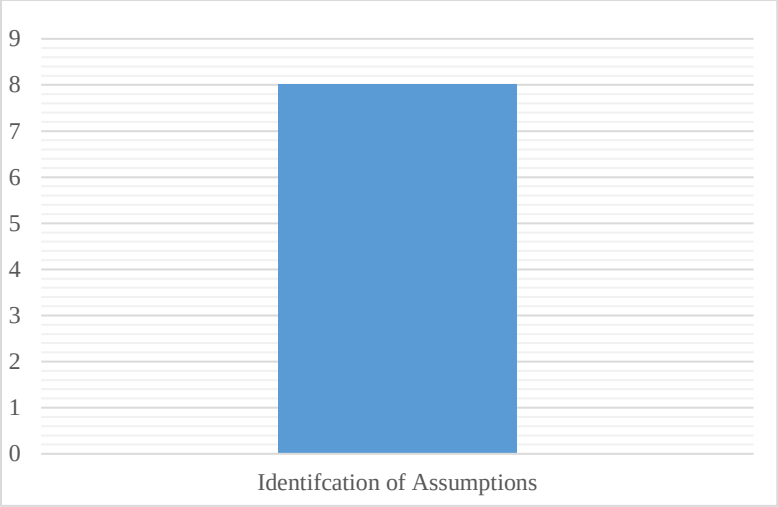

Figure 5.15 N-gram 49 the airplane rodeo information we assumed

5.3.2 Net Zero Energy Assignment

In this section I provide the results for formulaic language that were coded for the Net Zero Energy Assignment, students' second assignment with a problem statement. After overlap within the top 20 frequent instances of formulaic language were identified, I coded seven n-grams for the rhetorical functions (e.g., steps) each performed. Table 5.3 provides the raw frequencies for the seven n-grams that were coded (15% of each); because the frequencies were quite high (all above 100), a minimum cut-off was not necessary. However, all instances coded have a raw frequency above 40, which is the typical minimum frequency established in research. Additionally, unlike the n-grams for the Airplane Rodeo assignment where six-word sequences were extracted, four-word sequences were extracted from the corpus for the Net Zero Energy assignment. Lastly, all n-grams observed in student writing were also observed in pedagogical materials as content words for their assignment.

Table 5.3 Net Zero Energy N-grams Coded for Rhetorical Function

Rank	Frequency	Range	N-gram
1	468	220	window to wall ratio
2	302	189	a net zero energy
3	216	152	of the building is
4	208	150	the biggest impact on
5	187	130	cost of the building
7	149	107	net zero energy building
8	140	107	number of solar panels

Figure 5.16 provides information for n-gram 1, *window to wall ratio.* Of the 428 concordance lines extracted from the corpus, 15% (n=64) were coded; 73.44% (n=47) were coded as Description of Final Design (DSFD), 15.63% (n=10) were coded as ITO, and 10.93% (n=7) were coded as Reflection of Decisions Made (REFL). 100% of the instances for n-gram 1 occurred in the solution-space; however, there were no clear patterns of order for these steps. DSFD, for example, was observed as occurring both at the end of the document after ITO, IL, and IA and also before ITO, IL, and IA. REFL generally was expected to occur at the end of the text as part of a conclusion, but REFL was also observed occurring throughout students' texts. Below are examples of each code for n-gram 1:

Example DSFD

- *Our apartment has 6 trees. Trees are desirable for a house and our apartment provides 6 of them. Trees are inexpensive and add to the curb appeal of the apartment. Window to wall ratio also helps with curb appeal.*

EXAMPLE ITO

- *In addition to the trees, we increased the window size to increase the window to wall ratio, added shutters to increase symmetry about the whole building, and decreased the size of the solar panels to reduce the cost.*

Example REFL

- *Some improvements that could be made to building the is making it more desirable. This would mean adding more trees outside of the building and making a greater window to wall ratio. Also adding more room for each resident would make the building better as they would have more space to live. Another improvement would be making the foundation smaller.*

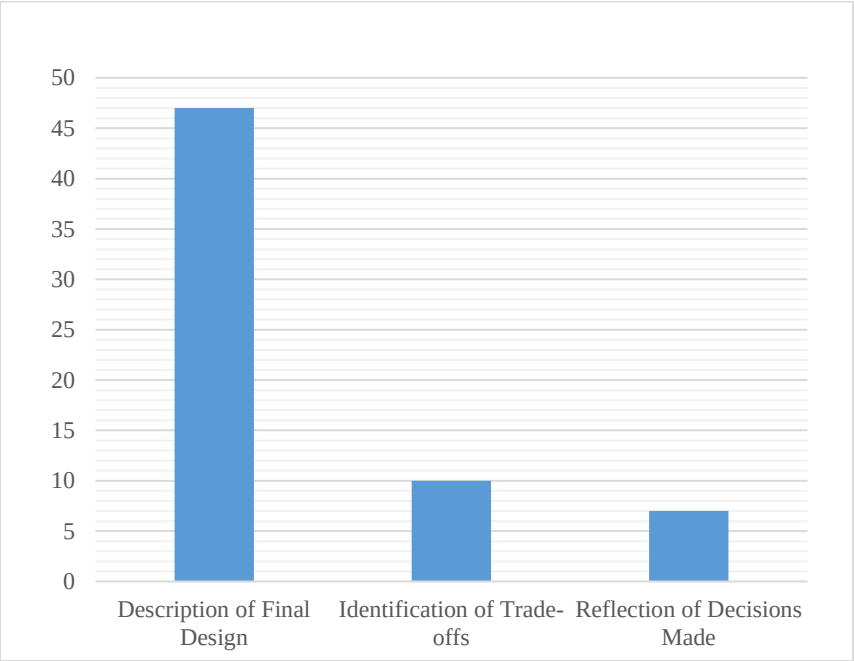

Figure 5.16 N-gram 1 window to wall ratio

Figure 5.17 provides information for n-gram 2, *a net zero energy*. Of the 302 concordance lines extracted from the corpus, 15% (n=45) were coded; 31.11% (n=14) were coded as CN, 15.55% (n=7) were coded as Justification of Problem (JP), 15.55% (n=7) were coded as REFL, 6.7%

(n=3) were coded as ITO, 6.7% (n=3) were coded as ITO, 2.2% (n=1) were coded as IC, 2.2% (n=1) were coded as IC2, and 2.2% (n=1) were coded as IL. All instances for CN, IC, and IC2, occurred in the problem-space, while all instances for DSFD, ITO, and IL occurred in the solution space. JP and REFL did not have clear boundaries between problem- and solution-spaces, often occurring in either space. However, if JP occurred in the problem-space it was generally after CN, offering context for the needs of the client. Additionally, net-zero was not consistently hyphenated in students' texts, as the examples below demonstrate. Not surprisingly, given that *net-zero* is an important content word for the assignment, n-gram 2 had the most variation in rhetorical functions it performed for this assignment.

Example CN:

- *The client, Purdue University, needed a design <u>for a net-zero energy</u> residence unit for students.*

Example JP:

- *The goal is important because having <u>a net zero energy</u> building is crucial nowadays to attain a sustainable and healthy environment in the future.*

Example REFL:

- *Additionally, we became more well versed in the process that architects and engineers go through when creating <u>a net zero energy</u> building.*

Example DSDF

- *The largest factor on the price is the walls which were 30.88% and the solar panels which were 23.35%. These two factors are synonymous since increasing the number of walls increases the total energy need and thus you have to increase the amount of solar panels to maintain <u>a net-zero energy</u> model.*

Example ITO

- *His design did cost a little more than we allowed for in our budget, but we made a compromise because he effectively designed a net-zero energy building.*

Example IC

- *The key criteria are. will be low cost, be a net-zero energy consumer, aesthetically pleasing, and have four, four person apartments with two apartments on each floor.*

Example IC2

- *A main constraint for a net-zero energy building is that annual energy usage must be 0 k Wh or less.*

Example IL

- *Additionally, the actual time given to design a net zero energy building was its own limitation.*

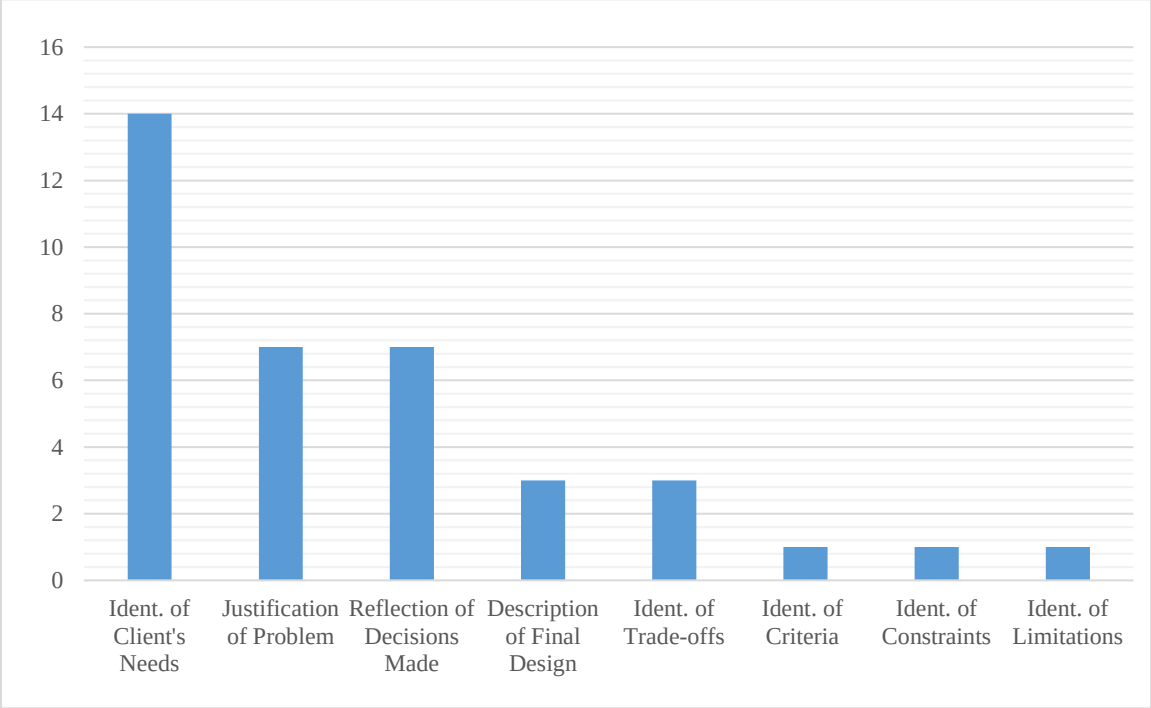

Figure 5.17 N-gram 2 a net zero energy

Figure 5.18 provides information for n-gram 3, *of the building is*. Of the 216 concordance lines extracted from the corpus, 15% (n=32) were coded; 81.3% (n=26) were coded as DSFD; 12.5% (n=4) were coded as ITO; 3.1% (n=1) were coded as IC; 3.1% (n=1) were coded as IL. All codes, excluding IC, were located in the solution-space. All DSFD codes occurred either before students mentioned ITO, IL, and IA, or directly after. Below are examples of each code.

Example DSFD

- *Lastly, the roof <u>of the building is</u> a standard shed roof, which is easy to construct and allows for maximal sun exposure on the solar panels.*

Example ITO

- *The cost <u>of the building is</u> medium, but it is big enough for sixteen people to live very comfortably. We traded off reducing the size of the windows and the height of the building in order to reduce cost and increase energy efficiency.*

Example IC

- *For the criteria of cost, the criteria are met since the total cost <u>of the building is</u> 307,528, which is lower than 320,000 budget.*

Example IL

- *A limitation <u>of the building is</u> the budget, since we had a limited budget we did not have the money to be able to have bigger building which sacrifices desirability.*

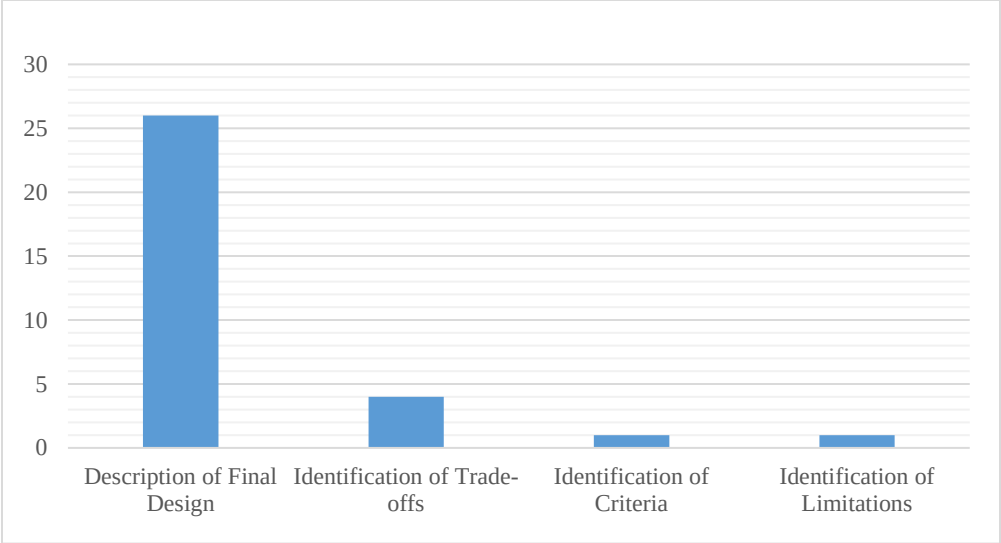

Figure 5.18 N-gram 3 of the building is

Figure 5.19 provides information for n-gram 4, *the biggest impact on*. Of the 208 concordance lines extracted from the corpus, 15% (n=31) were coded; 100% of all instances were coded as DSFD. Slightly more than half (n=16) of n-gram 4 occurred at the beginning of sentences (such as the example below), addressing either cost or energy, both of which linked back to criteria and constraints.

Example DSFD

- *The energy value of our design is highly negative providing evidence that we superbly met the net zero requirements asked by Mitch Daniels. <u>The biggest impact on</u> cost was the walls, and perhaps changing the material of the walls could bring the overall cost down and make the construction much more affordable.*

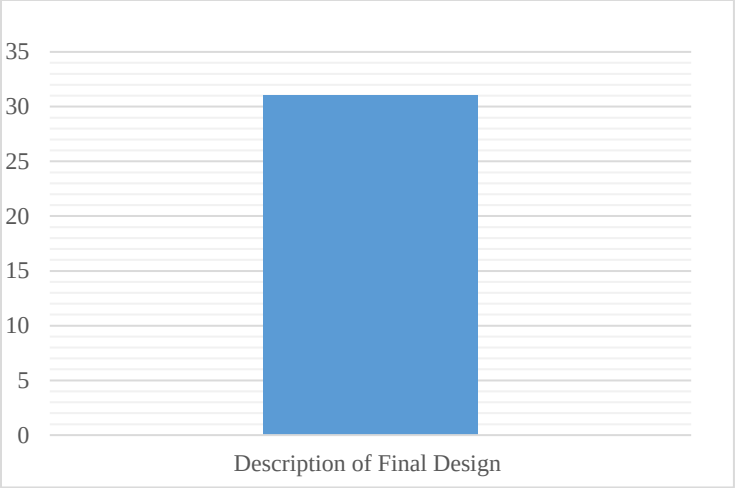

Figure 5.19 N-gram 4 the biggest impact on

Figure 5.20 provides information for n-gram 5, cost of the building. Of the 187 concordance lines extracted from the corpus, 15% (n=28) were coded; 53.6% (n=15) were coded as DSFD; 14.3% (n=4) were coded as ITO; 14.3% (n=4) were coded as REFL; 14.3% (N=4) were coded as IC2; 3.5% (n=1) were coded as IL. All instances for n-gram 5, excluding 3 instances for IC2, occurred in the solution-space.

Example DSFD

- *By far the largest cost of the building is the walls. This is due to the fact that they make up the greater part of the house.*

Example ITO

- *We feel these trade-offs are trivial in relation to the desirability, low energy consumption, and reasonable cost of the building.*

Example REFL

- *To conclude, we could improve the model by taking into account and evaluating some of the limitations. It would be beneficial to include a garage in the apartment because most*

students living on campus have cars. This would up the cost of the building, but it would appeal to the inhabitants much more.

Example IC2

- *However, we also have to consider the cost of the building which has to be under $480,000.*

Example IL

- *The cost of the building was a key component to the creation of the building because it places limitations on the materials.*

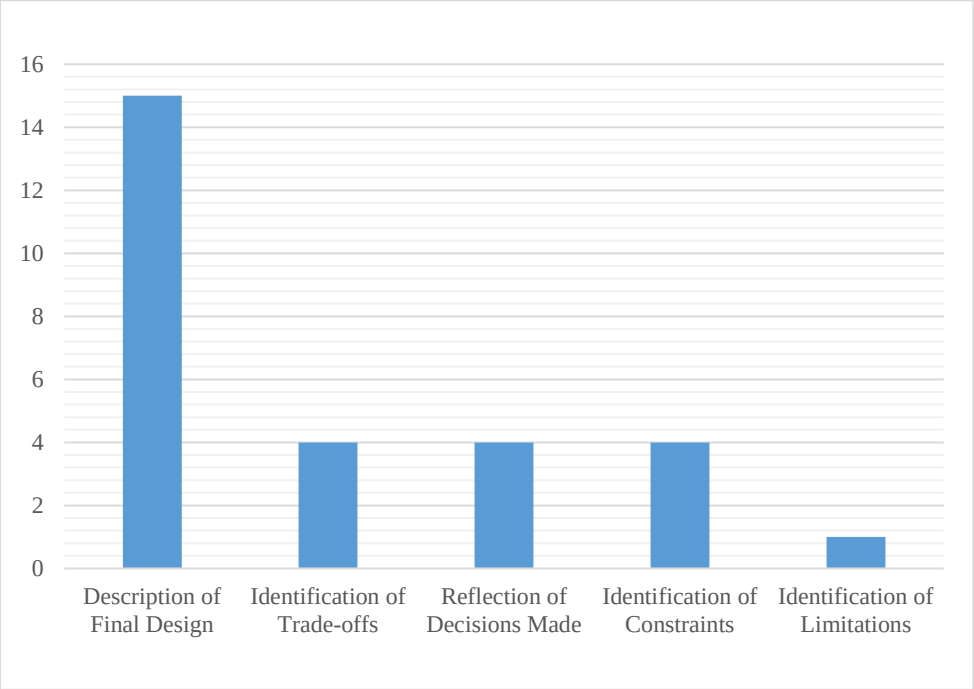

Figure 5.20 N-gram 5 cost of the building

Figure 5.21 provides information for n-gram 7, net zero energy building. Of the 149 concordance lines extracted from the corpus, 15% (n=22) were coded; 31% (n=7) were coded as DSFD; 27.2% (n=6) were coded as REFL; 18.1% (n=4) were coded as CN; 9.1% (n=2) were coded as IC2; 9.1% (n=2) were coded as IL; 5.5% (n=1) were coded as JP. IC2 and CN were the only

codes that occurred in the problem-space, with the other three codes observed in the solution-space.

Example DSFD

- *The final design of the Net Zero Energy building is L-shaped with several windows on each highly insulated wall and includes roof solar panels to generate energy.*

Example REFL

- *The key learning in this design analysis is that there is no perfect net zero energy building, for tradeoffs will constantly have to be made and the building will have to be iterated upon until a satisfying balance of needs and criteria are found.*

Example IC2

- *Some constraints are a cost constraint of $350,000, the size of the building needs to comfortably fit 16 people, it needs to be a net zero energy building, each side of the apartment building must have at least two windows on each floor, tree trunks must be at least two meters away from the building...*

Example IL

- *Our design was limited by possible expenses and the need for a net-zero energy building.*

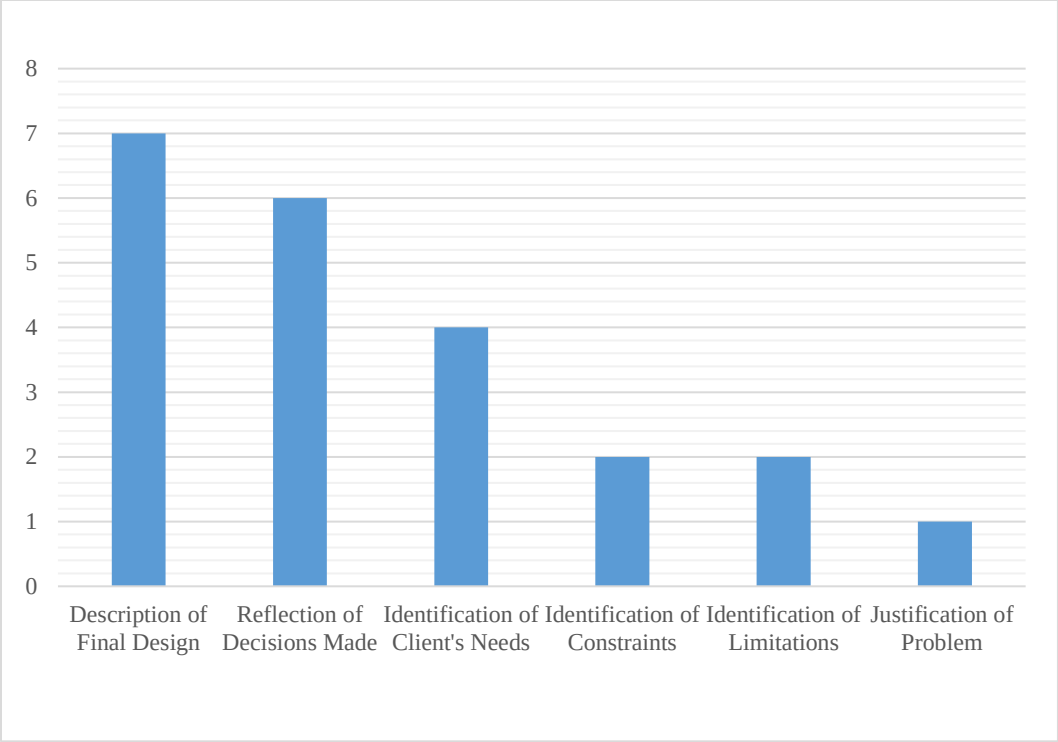

Figure 5.21 N-gram 7 net zero energy building

Figure 5.22 provides information for n-gram 8, *number of solar panels.* Of the 149 concordance lines extracted from the corpus, 15% (n= 20) were coded; 85% (n=16) were coded as DSFD; 5% (n=1) were coded as IL; 10% (n=2) were coded as ITO. All instances of n-gram 8 occurred in the solution-space.

Example DSFD

- *The total cost of the building is $392,486. The building is expensive in large part due to the high number of solar panels, which make up 29.81% of the total cost. Additionally, the large foundation makes up almost a quarter of the final cost.*

Example IL

- *A limitation of this design is that it cannot easily be changed to be used for other applications. For example, slight changes in the number of solar panels, size, or color of the building make the building consume net energy.*

Example ITO

- *But again, the increase in the number of solar panels increased the total cost of the building.*

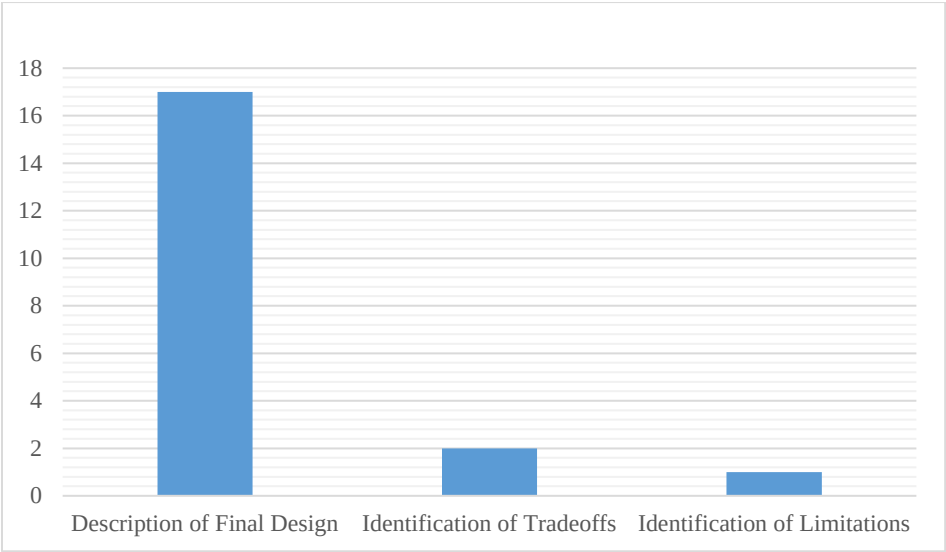

Figure 5.22 N-gram 8 number of solar panels

5.3.3 Final Assignment

After overlap within the top 20 frequent instances of formulaic language in the third assignment, Final Design Project, were identified, I coded nine n-grams for the rhetorical functions (e.g., steps) each performed. Table 5.4 provides the raw frequencies for the nine n-grams that were coded (15% of each). Unlike with the first two assignments, frequencies for formulaic language in the third assignment were comparatively low with n-gram one having the highest at 54 (compared to n-gram 1 in the first assignment with a frequency of 343 and n-gram 1 in the second assignment with a frequency of 468). However, because I am interested in analyzing the steps and moves these n-grams perform and any variation that exists between and within each writing task, I opted to for a minimum frequency cut-off of 30, which is below the typical minimum frequency observed in research. Additionally, unlike the n-grams for the Airplane

Rodeo assignment where six-word sequences were extracted, four-word sequences were extracted from the corpus for the final design project assignment. Lastly, all n-grams observed in student writing were also observed in pedagogical materials as content words for their assignment.

Table 5.4 N-grams for Final Project

Rank	Frequency	Range	N-gram
1	54	43	the product must be
3	39	38	the client kimberly clark
4	38	26	waste of unused product
6	34	22	the amount of waste
7	34	12	the tumaini innovation center
8	34	33	this problem is important
10	32	18	the needs of the
11	31	25	recycled reused or repurposed
13	30	22	the cleanliness of the

Figure 5.23 provides information for n-gram 1, *the product must be*. Of the 54 concordance lines extracted from the corpus, 15% (n=8) were coded; 87.5% (n=7) were coded as IC2 and 12.5% (n=1) were coded as IC. The majority of instances occurred in the problem-space; however, a few were located in the solution-space after a description of the final solution. Below are examples of each code for n-gram 1:

Example IC2

- *<u>The product must be</u> upcycled, or constructed of used/recycled material, increasing the value of the material. The product must be desirable so that students wish to purchase the product.*

Example IC

- *The criteria for this problem are that <u>the product must be</u> able to be created simply and cheaply so a working prototype can be manufactured and that it must adequately protect a bicycle from inclement weather.*

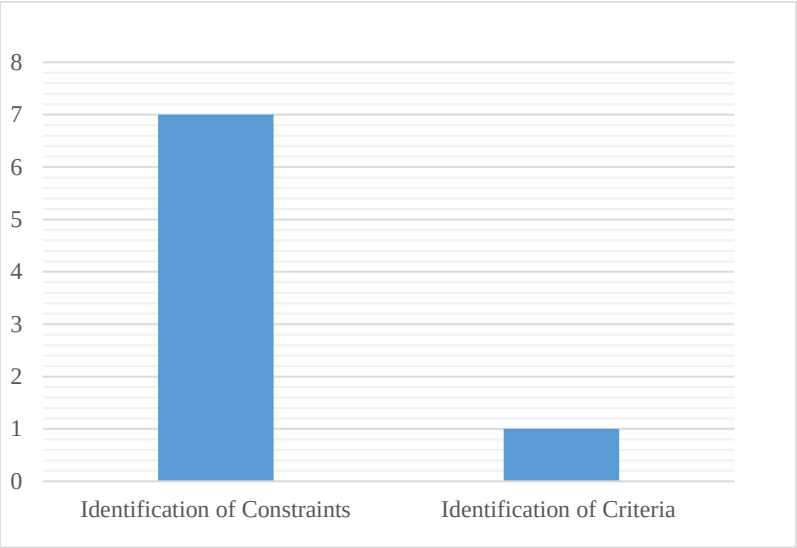

Figure 5.23 N-gram 1 the product must be

Figure 5.24 provides information for n-gram 3, *the client kimberly clark*. Of the 39 concordance lines extracted from the corpus, 15% (n=6) were coded; 100% of instances were coded as CR. All instances occurred at the beginning of the document and were appositives. Interestingly, the structure for CR mirrors that from the first assignment, Airplane Rodeo.

Example CR

- *The client, Kimberly Clark Professional, is constantly trying to improve their customer and consumer experience, and they are in need of a mathematical model based on data to provide a cleaning schedule for an entire building.*

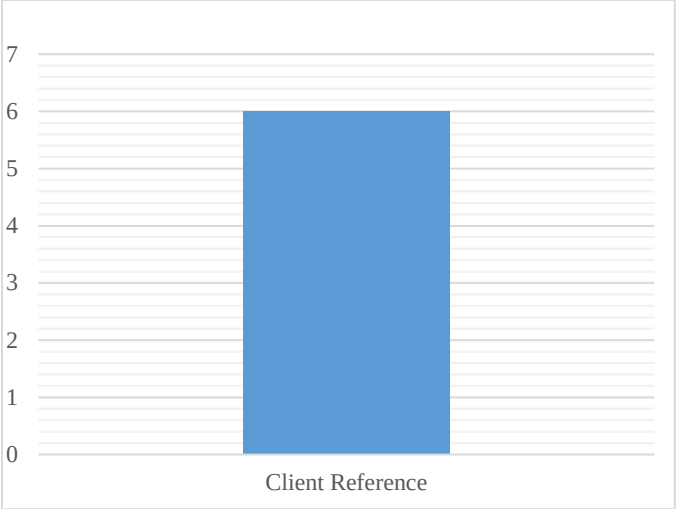

Figure 5.24 N-gram 3 the client kimberly clark

Figure 5.25 provides information for n-gram 4, *waste of unused product*. Of the 38 concordance lines extracted from the corpus, 15% (n=6) were coded; 67% were coded as IC and 33% (n=2) were coded as CN. All instances coded occurred in the problem-space; conversely, the problem-space was not always present at the beginning of the document, but often in the middle after students contextualized the problem. Although IC mentions "the solution" it does not refer to a specific, determined solution; rather, students are abstractly mentioning that a solution is needed and what the requirements are for that solution. At times, students combined both IC and CN, stating IC as the client's need. Below are examples for IC and CN:

Example IC

- *The solution will be the most effective when it reduces* <u>*waste of unused product*</u>*, maximizes cleaning productivity while minimizing human touch time, keeps the restroom clean, keeps products available, and is adaptable to fit multiple locations and types of bathrooms*

Example CN

- *Our client, KC Professional, needs a mathematic model to optimize a weekly maintenance schedule and eliminate waste of unused product for restrooms in Purdue without sacrificing cleanliness or usability.*

Figure 5.25 N-gram 4 waste of unused product

Figure 5.26 provides information for n-gram 6, *the amount of waste*. Of the 34 concordance lines extracted from the corpus, 15% (n=5) were coded; 60% (n=3) were coded as DSFD; 20% (n=1) were coded as IC; 20% (n=1) were coded as IC2. All instances of DSFD occurred in the solution-space while IC and CN occurred in the problem-space. DSFD codes often included the use of personal and possessive pronouns. Interestingly, as the IC example shows, students often added sign-posts followed by lists for their criteria and constraints for the final assignment. Although, their lists were written in narrative format and not bullets; this is another strategy that is observed in the first assignment.

Example DSFD

- *Our product, being completely made from recyclable plastic and earth sediment, will reduce the amount of waste from the refugee camps. It is economically feasible because if it were to be sold, its value is higher than the construction cost.*

Example IC

- *Criteria: A Static maintenance and cleaning model, specifying optimum cleaning times, which can be applied to any bathroom in Purdue University. A model that will reduce the number of touch times for maintenance staff. A model that will reduce the amount of waste thrown out and "wasted" because it is unused. A model that is simple enough so that it is easy to use and understand it.*

Example IC2

- *The solution should also minimize the amount of waste produced in the bathroom.*

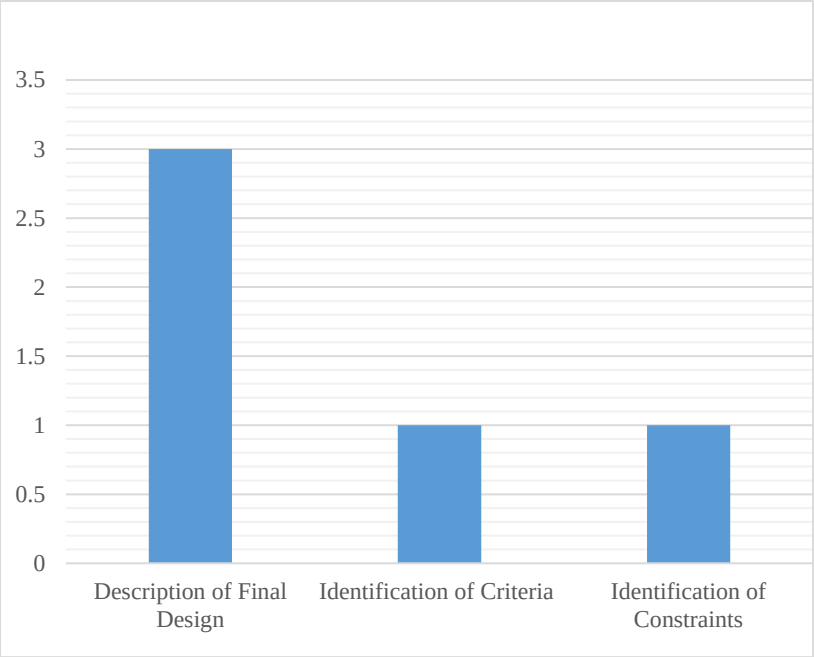

Figure 5.26 N-gram 6 the amount of waste

Figure 5.27 provides information for n-gram 7, *the tumaini innovation center*. Of the 34 concordance lines extracted from the corpus, 15% (n=4) were coded; 20% (n=1) were coded as CR; 20% (n=1) were coded as IC2; 20% (n=1) were coded as JP; 20% (n=1) were coded as REFL; 20% (n=1) were coded as DSFD. CR and IC2 were steps in the problem-space while JP, REFL, and DSFD were steps in the solution-space.

Example CR

- *The clients were the Tumaini Innovation Center, and the direct users were the students at the Tumaini Innovation Center.*

Example IC2

- *The final design must also make use of or be made out of reused/recycled/recyclable materials. This may include scrap metal/wood, glass, and other resources <u>that the Tumaini Innovation Center</u> already has.*

Example JP

- *Kenya is an example of a developing country that recognize the need for improvement in the education system, and is seeking to do so. <u>The Tumaini Innovation center</u> in particular.*

Example REFL

- *We then performed research on the three top ideas to analyze how well they perform as it relates to the metrics chosen. A weighted decision matrix was then used to finalize our top design choice, the solar steam generator. The final step was to create a value proposition for the client and the user, which in this case were <u>the Tumaini Innovation Center</u> and the students, respectively. We brainstormed and generated more than 50*

ideas and we finally got it down to 3 top ideas, which were solar steam generator, solar oven and solar voltmeter.

Example DSFD

- *This way, the users, students, can see how the car functions visually, and stakeholders can see how it relates to their overarching goal for the Tumaini Innovation Center.*

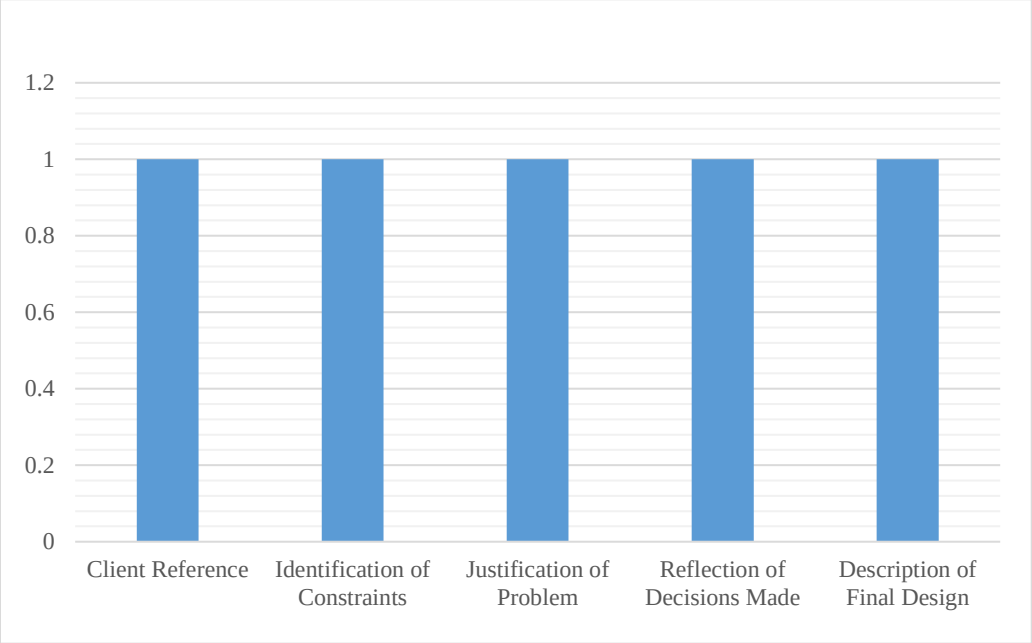

Figure 5.27 N-gram 7 the tumaini innovation center

Figure 5.28 provides information for n-gram 8, *this problem is important*. Of the 34 concordance lines extracted from the corpus, 15% (n=5) were coded; 100% were coded as JP. 80% (n=4) of all JP instances occurred at the beginning of the sentence with *this* as a nonreferential pronoun. Two of the codes occurred in the problem-space, contextualizing the client's need(s), while the remaining three codes occurred in the solution-space towards the conclusion of their executive summary.

Example JP

- *<u>This problem is important</u> to solve because students can spend up to 40 minutes walking from class to class on larger campuses and, if it were raining during this time, the students would get drenched.*

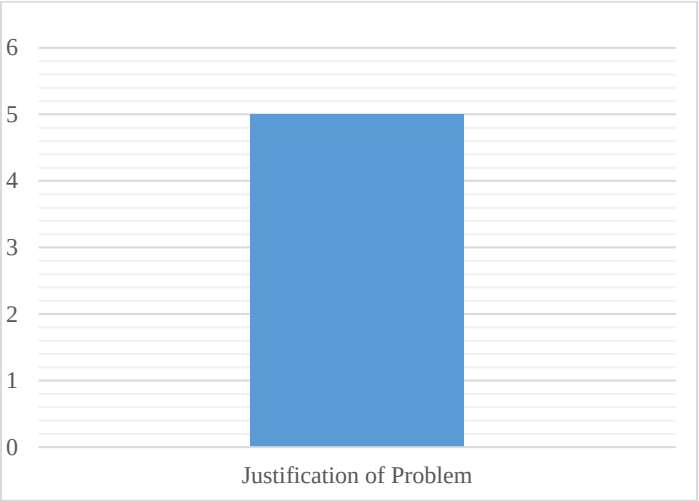

Figure 5.28 N-gram 8 this problem is important

Figure 5.29 provides information for n-gram 10, *the needs of the*. Of the 32 concordance lines extracted from the corpus, 15% (n=5); 40% (n=2) were coded as CN; 40% (n=2) were coded as DSFD; 10% (n=1) were coded as REFL. CN was the only code for n-gram 10 that occurred in the problem-space, with the DSFD and REFL in the solution-space.

Example DSFD

- *Our product meets <u>the needs of the</u> client as it will be made from used/upcycled shingles.*

Example CN

- *<u>The needs of the</u> other stakeholders, which include professors, students, and visiting guests, are defined by the resource efficiency and production satisfaction criteria in the second paragraph.*

Example REFL

- *Ultimately, we chose to use our computer program due to its ease of use for the janitors as well as the adaptability of this model. We decided to trade of the preciseness of our second choice to instead obtain our current model, which is easily usable and adaptable to more bathrooms on campus. We concluded this fulfills the needs of the client more sufficiently.*

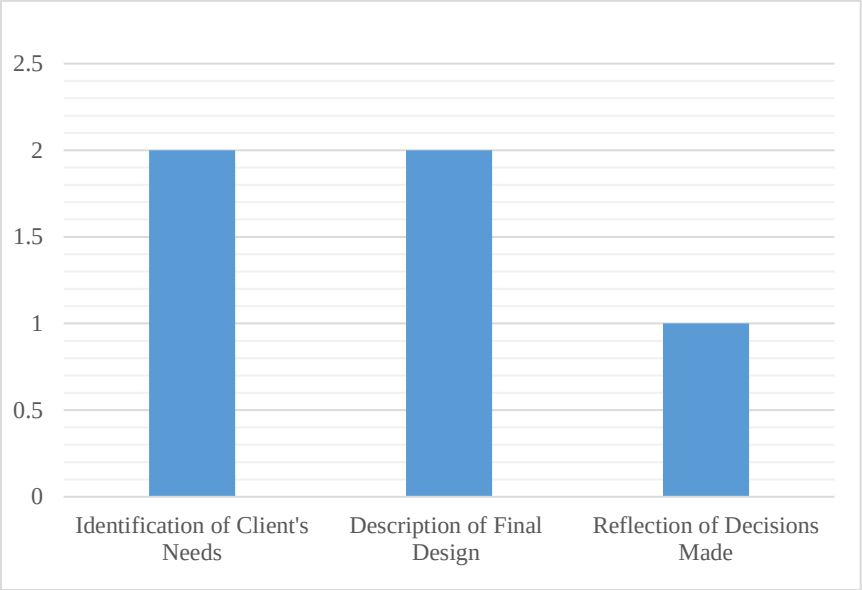

Figure 5.29 N-gram 10 the needs of the

Figure 5.30 provides information for n-gram 11, *recycled reused or repurposed*. Of the 31 concordance lines extracted from the corpus, 15% (n=5) were coded; 60% were coded as CN and 40% (n=2) were coded as IC2. All instances for n-gram 11 occurred in the problem-space.

Example CN

- *The goal of Tumaini's 'Upcycling Design Challenge' is to develop a product out of recycled, reused, or repurposed materials that educates engineering concepts to secondary-level students.*

Example IC2

- *The product is to be made up of <u>recycled, reused, or repurposed</u> material. It should utilize multiple types of recycled material as possible.*

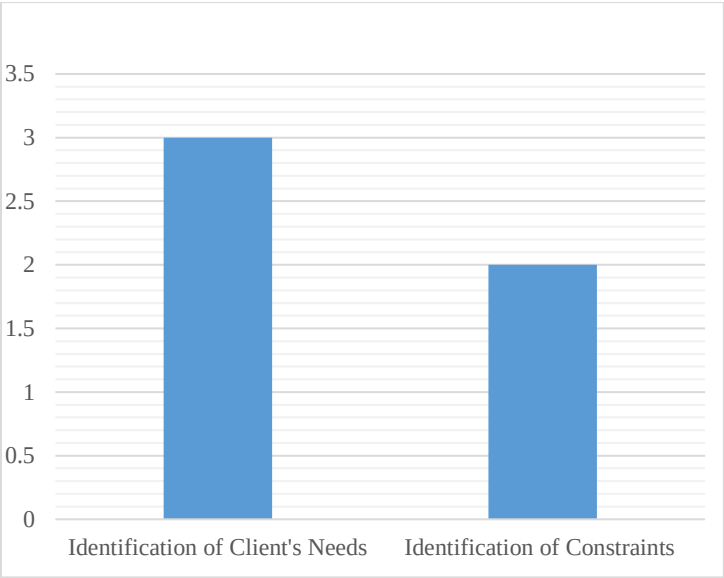

Figure 5.30 N-gram 11 recycled reused or repurposed

Figure 5.31 provides information for n-gram 12, *the cleanliness of the*. Of the 30 concordance lines extracted from the corpus, 15% (n=5) were coded; 60% (n=3) were coded as DSFD; 20% (n=1) were coded as CN; 20% (n=1) were coded as IC.

Example DSFD

- *In regard to <u>the cleanliness of the</u> restroom, if there are one or more pieces of trash the floor, staff should pick it up. Each of these processes take place in three visits throughout the day-One visit 8:30am, one at 2:00pm, and one at 8:30pm.*

Example CN

- *The Kimberly-Clark Corporation, Purdue University Management, Purdue Maintenance Staff and Purdue Students are all trying to increase the efficiency of campus bathroom*

cleaning staff, reduce the amount of waste generated by bathrooms, increase the cleanliness of the bathrooms and ensure the bathrooms are always fully stocked.

Example IC

- *Kimberly Clark wants a weekly schedule of bathroom maintenance and the criteria are minimizing unused waste, optimizing the maintenance efficiency (human touch time), while maintaining or increasing the cleanliness of the bathrooms.*

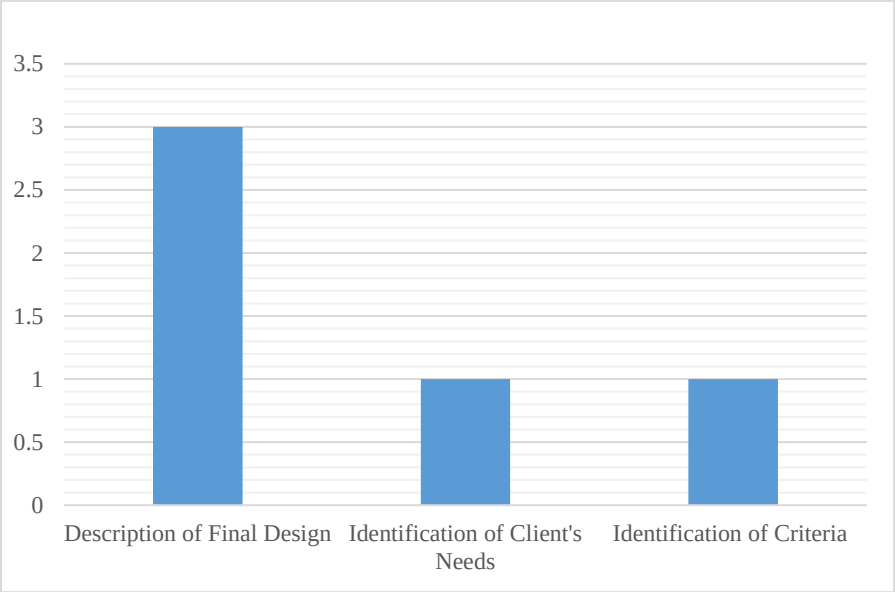

Figure 5.31 N-gram 13 the cleanliness of the

5.4 Discussion

5.4.1 Rhetorical Moves & Steps of Problem Statements

In section 5.2, I provided the result for the following research question:

1. What are the expected rhetorical moves and steps for problem statements and the immediately surrounding text?

In summary, the expected rhetorical moves and steps for problem statements appear to be influenced by the instructor of the course and the pedagogical materials. In general, however, students are expected to achieve the following steps:

1. a direct reference to a client;
2. an identification of the client's needs;
3. an identification of criteria; and
4. an identification of constraints;

These steps, however, are most observed in The Airplane Rodeo Assignment (I will discuss more about this in section 5.4.3), where students typically followed the genre conventions and formula provided to them in the template (see Figure 5.1). As the student example in Figures 5.3, 5.4, and 5.5 demonstrate, there was meaningful variation in how students performed these moves and steps, even within the same groups. For example, in Figure 5.3, students used three sentences to achieve these moves, using the exact formula in the template provided to them, down to even the linguistic features used to represent these moves. In Figure 5.4, however, students wrote a single sentence, just over 2 lines total, for their problem statement; faculty did not find this ineffective because, according to Dr. Reis, this sentence provides information on who the client is, what the problem is, problem specifications (e.g. criteria and constraints). However, although students did provide the required content in their problem statement, the structure of it reads more as a mission statement, something similar to what one might find on a resume, especially considering that it starts with a verb and does not have an active subject:

> Help the mayor of Indianapolis to find ways to reduce the amount of the CO2 emissions within Indianapolis by using solar panels and determine if this would be a cost efficient and useful change.

It is inferred from the context that the client for this project is the mayor of Indianapolis (step 1) the problem at hand is the amount of CO2 emissions (step 2), and the criteria and constraints are that the solution must be cost efficient and useful (steps 3 and 4); in addition to this, students

provide the solution (solar panels) within the problem statement. Based on faculty perceptions (chapter 4), the addition of the solution in the problem statement is not an effective strategy for writing problem statements.

In their third assignment (Figure 5.5) students return to three sentence structure for the problem statement and make a clearer distinction between the problem space and the solution space, similar to their first assignment.

> During the winter months in the West Lafayette region, college students and faculty have to withstand extreme temperatures. The clothing that people use in order to stay warm, though it does the job, is rarely made of materials that are recycled or recyclable. There needs to be clothing available that is made of recycled fabrics so that it addresses the people's need to stay warm during the winter and at the same time, is made of environmentally-friendly materials so people can choose to be more environmentally-conscious.

The differences here, however, are that students begin with a contextualization of the problem, referencing potential users (e.g., faculty and students) rather than a client. It might be inferred that the client is Purdue University given the location and the reference to the potential users. In the second sentence, students refer to what might be problem specifications, “recycled or recyclable,” followed by the third sentence where the need is explicitly stated with another reference to the problem specifications, or specifications for a good solution. Unlike in their second assignment, students do not explicitly state their preferred solution in their problem statement. What is immediately noticeable in students writing is aligned with Conrad’s (2018) findings that students are using longer sentences to possibly appear more “eloquent,” where shorter, more concise sentences using the formulaic language from the first assignment might be

more effective. In addition, students are not following the expected structure and organization that faculty expressed during their interviews. Moreover, aside from mentioning "needs," which Dr. Robins indicated is also a "particular language or jargon" specific to engineering, students are not using any of the expected terminology (e.g., client, user, criteria, and constraints) in their problem statements. Terminology associated with the problem statement does not occur until students move into the solution space (see Figure 5.5), where they provide a detail description of their final product, a beanie. In chapter 4, faculty discussed the importance of students being able to distinguish between problems and solutions and identifying potential audiences for each one; while this is just one example of students' entangling problems and solutions, many of the examples that I qualitatively examined from the corpus had a difficult time organizing not only the expected rhetorical steps for their problem statements, but the overall content in their executive summaries – this was a finding that faculty also confirmed during our interviews.

There are a plethora of potential reasons for the writing strategies that students opted to use (and not use) throughout all three assignments. One factor that comes into play, which was observed in Chapter 4, is how the pedagogical materials influence students' writing and overall effective communication. While The Airplane Rodeo Assignment provides a template for students to use, and there is room for students to deviate from the formula, the rest of the assignments do not provide such a formulaic structure for how students should write their problem statements. The Net Zero Energy Assignment and the Final Design Project provide outlines and supplementary materials that ask students to critically engage with a variety of audiences and the context of the problem they are addressing (e.g., the problem scoping handout), there is no indication of any specific language and sentence-level order that students should adhere to for problem statements – at least not in the materials collected and analyzed. As

the findings in sections 5.31. 5.32, and 5.3.3 demonstrate, students do use the formulaic language from the pedagogical materials; what students are not necessarily internalizing, however, is genre knowledge appropriate for the documents they are writing. Lack of genre awareness and knowledge of the appropriate conventions for communicating discipline-specific information appears to negatively impact students' ability to effectively communicate.

5.4.2 Formulaic Language and Generic Expectations

In section 5.3.1, I provided the results for the following research questions:

1. What formulaic language represents the rhetorical moves and steps associated with problem statements?
2. Do students use the formulaic language from the pedagogical materials across all three assignments?

In summary, there are differences that exist between the three assignments in terms of which formulaic language represent which moves and steps for problem statements, and the distribution of steps across the assignments. These differences appear to be largely influenced by the pedagogical materials and the content provided to students. For example, in the Airplane Rodeo assignment, the use of possessive adjectives and plural pronouns were observed in the pedagogical materials and students' texts; all 10 6-word clusters (see Table 5.4) identified and coded for in the sub-corpus for this assignment were also identified in the pedagogical materials. Students' adoption of specific linguistic features including non-referential pronouns, possessive adjectives, and plural pronouns are possibly influenced by their appearance in the pedagogical materials. The language identified for the problem space, in both the pedagogical materials and students' texts, appears more objective and detached; whereas, the pedagogical materials, as reflected in students' texts, guide students towards more active and subjective language in which

students begin to take ownership of the solution(s) they design. Additionally, the pedagogical materials for the first assignment are more constrained, and there is less room for students to deviate from the formulas provided to them, and the presence of idiosyncratic language is less frequent in the first assignment compared to the second and third assignments. As students progress to the second assignment, Net Zero Energy, the problems and the pedagogical materials become less constrained and students are asked to engage on a more critical level with more open-ended problems. As such, the problem statement was not easily identifiable and I opted to analyze executive summaries for the second and third assignments, where the problem statements are expected to live. My decision to do this may speak to why there was more variation in the steps that existed within the second and third assignment when compared to the first assignment. However, the sub-corpus for the first assignment does include both the problem space and the solution space, as do the sub-corpora for the second and third assignment.

The total number of n-grams coded for The Airplane Rodeo is 264; the total number of n-grams coded for The Net Zero Energy Assignment is 230; the total number of n-grams coded for The Final Design Project is 44. What is immediately noticeable across the three assignments is that there is more variation and greater distribution of the rhetorical steps in the second assignment when compared with the first and third. In The Airplane Rodeo Assignment, no one n-gram performed more than two rhetorical steps at a time, whereas in The Net Zero Energy Assignment one n-gram (Figure 5.17) performed eight rhetorical functions across both the problem space and the solution space. Additionally, the majority (88%; n=203) of the rhetorical functions coded for the Net Zero Energy assignment were categorized in the solution space. Interestingly, 60.23% (n= 159) of the n-grams coded for The Airplane Rodeo assignment occurred in the problem space, and 63.63% (n=28) of the n-grams coded for The Final Design

Project also occurred in the problem space. While the n-grams across the assignments were not the same, all n-grams coded were also identifiable in the pedagogical materials.

Some linguistic markers for the solution-space include the use of possessive adjectives and plural pronouns. Additionally, language is less abstract, and more specific as students describe and explain their solutions. Examples of some differences in the linguistic devices students used are: DSFD (description of final solution) present tense with possessive adjectives (e.g., our); ITO (identification of trade-offs), IL (limitations), and IA (assumptions) included active voice with plural possessive pronouns (e.g., we) and past tense, and, more interestingly, language that reflected REFL (reflective writing) tended to use more modals with passive voice, specifically modals that fall under the categories of permission/ability and volition/prediction (see Biber, Conrad, & Leech, 2002) including *could* and *would*, respectively. Interestingly, *would* is observed more in conversation registers rather than academic registers (see Biber, Conrad, & Leech, 2002).

CHAPTER 6. CONCLUSION

6.1 Introduction

This chapter has three key sections: (1) summary of key findings with relation to the research questions; (2) implications for pedagogical interventions in FYE using an ESP framework of genre analysis; and (3) limitations of the research and future directions are discussed.

6.2 Summary of Key Findings

The purpose of this dissertation was multifaceted: (a) to explore how FYE faculty engage with the ABET learning outcome "an ability to communicate effectively" and how their expectations for effective communication materialize through the pedagogical materials and their assessment of student writing; (b) to identify the generic conventions and purposes of problem statements, a rhetorical move frequently observed in the introductions of various genres written in FYE (e.g., technical briefs, technical memos, and design reports); and (c) to explore the relationship between FYE faculty perceptions of effective communication, the genre conventions for problem statements, and the writing that L1 and L2 students produce in ENGR 131. Table 4.1 outlines the seven elements of effective communication that FYE noted as important for first year students to adequately and accurately address for their writing to be considered effective:

1. Audience Awareness
2. Specificity of Content & Data
3. Organization, Structure, & Logical Flow
4. Reflective Writing Strategies
5. Vocabulary & Discipline-specific Meanings

6. Impact of Pedagogical Materials
7. Style

Much of the research on effective communication in engineering disciplines supports many of the elements that FYE faculty emphasized, specifically Audience Awareness, Specificity of Content and Data, Organization, Structure, and Logical Flow, Clear and Concise Writing, and Mechanics, Grammar, Punctuation, and Syntax (see Boisarsky, 2004; Conrad, 2017, 2018; Ford & Teare, 2006; Williams, 2002; Yalvac et al, 2007). What I think is interesting is that outside of ESP scholarship, Vocabulary and Discipline-Specific meanings are generally not addressed in engineering-specific scholarship or in New Rhetoric approaches to genre theory and writing in the disciplines. On some level, all FYE faculty agreed that students' level of lexical proficiency did impact the effectiveness of their writing; students whose texts demonstrated a clear and discipline-specific understanding of key terms and phrases were assessed as more communicatively effective than their peers whose writing indicated a gap in understanding discipline-specific terms (e.g., *criteria, constraints, limitations, trade-offs*, and *assumptions*). Based on this observation, there appears to be a strong connection between students' lexical proficiency and development of procedural and conceptual knowledge; learning the conventions of an academic discourse community requires that writers are familiar with the expected rhetorical practices and genre conventions of that community, including the appropriate and accurate use of expected discipline-specific terms and chunks of language (Bamberg, 1983; Cortes, 2004).

Another interesting finding is the disagreement that arose in the interview data between the faculty and their expectations for the genre conventions first year students should adhere to. Dr. Robins, for instance, was interested in students providing a reflective component in their

writing, where students discuss the decisions they made during the design process, possible procedural changes they would make if they encountered a similar problem in the future, and explicit discussion on the difficulties and barriers they experienced during the project; this reflective component was also observed in the pedagogical materials for the Final Design Project. For Dr. Robins, this kind of post-mortem is acceptable and conditionally effective in the executive summary as a conclusion; "conditionally" because students are still expected to maintain elements of the effective communication including, appropriate syntax, grammar, mechanics, and punctuation and proper organization, structure, and logical flow. For Dr. Rodriguez, however, reflective writing is an indication that students are not aware of their potential audiences; executive summaries should not be long and encumbered with content that is not relevant to a client, user, or stakeholder. If students engage in reflective writing, Dr. Rodriguez finds it inappropriate for the executive summary. Dr. Reis felt similarly to Dr. Rodriguez, indicating that reflective language was "journal" like and that students' informal style and tone (writing as they talk) were ineffective strategies. Reflective writing as a strategy for writing-to-learn can be effective for building students' conceptual, procedural, and meta-cognitive knowledges; however, it may be confusing to ask students to include a reflective component in documents that are used to teach students how to communicate like engineers, especially as students transition from FYE to their respective sub-engineering disciplines. What is also interesting is that findings from Chapter 5 potentially support Dr. Reis and Dr. Rodriguez' intuition that students were "writing like they talk," particularly with the use of modals students used for reflective writing, which are most commonly observed in spoken registers. However, more research, particularly for register analysis, will need to be conducted in order to further unpack FYE faculty perceptions of students' writing.

Chapter 5 provided insights on how students use formulaic language from the pedagogical materials in their own writing. What is of particular interest here are the variations in the rhetorical functions that exist between the first, second, and third assignments. In the Airplane Rodeo Assignment, the most guided and restricted of the three, there was little variation in the rhetorical functions for the 10 n-grams coded; Figure 6.1 shows that the Airplane Rodeo Assignment n-grams performed six of the expected rhetorical functions: Client Reference, Identification of Client's Needs, Identification of Criteria, Identification of Limitations, Identification of Assumptions, and Identification of Trade-offs. The rhetorical function with most representation for the Airplane Rodeo Assignment was Identification of Criteria. A key rhetorical function that was found for this assignment was Identification of Constraints. The Net Zero Assignment showed a meaningful difference in variation compared to the Airplane Rodeo assignment, with majority of the n-grams falling in the solution space rather than the problem space. One potential factor contributing to this increase in variation might very well be because the n-grams identified in The Net Zero Assignment were much more topic-related compared to the first assignment. The majority of the n-grams for the Net Zero Assignment were coded as Description of Final Solution; rhetorical functions not accounted for in the Net Zero Assignment were: Identification of Assumptions and Client Reference. The Final Design Project, interestingly, demonstrated some striking similarities in the moves and steps achieved when compared to the Airplane Rodeo Assignment. The Final Design Project had seven rhetorical functions coded for with a fairly even distribution across those seven codes, excluding Reflection on Decisions Made. The distribution of the n-grams between the problem space and the solution are also similar between the first and last assignment, with the majority of the rhetorical functions being categorized under the problem space. The Net Zero assignment, however, shows

that students' use of formulaic language largely represented the solution space. Figures 6.1 and 6.2 provide a visual representation of the rhetorical functions coded for in each assignment and the distribution of those n-grams across the problem space and the solution space.

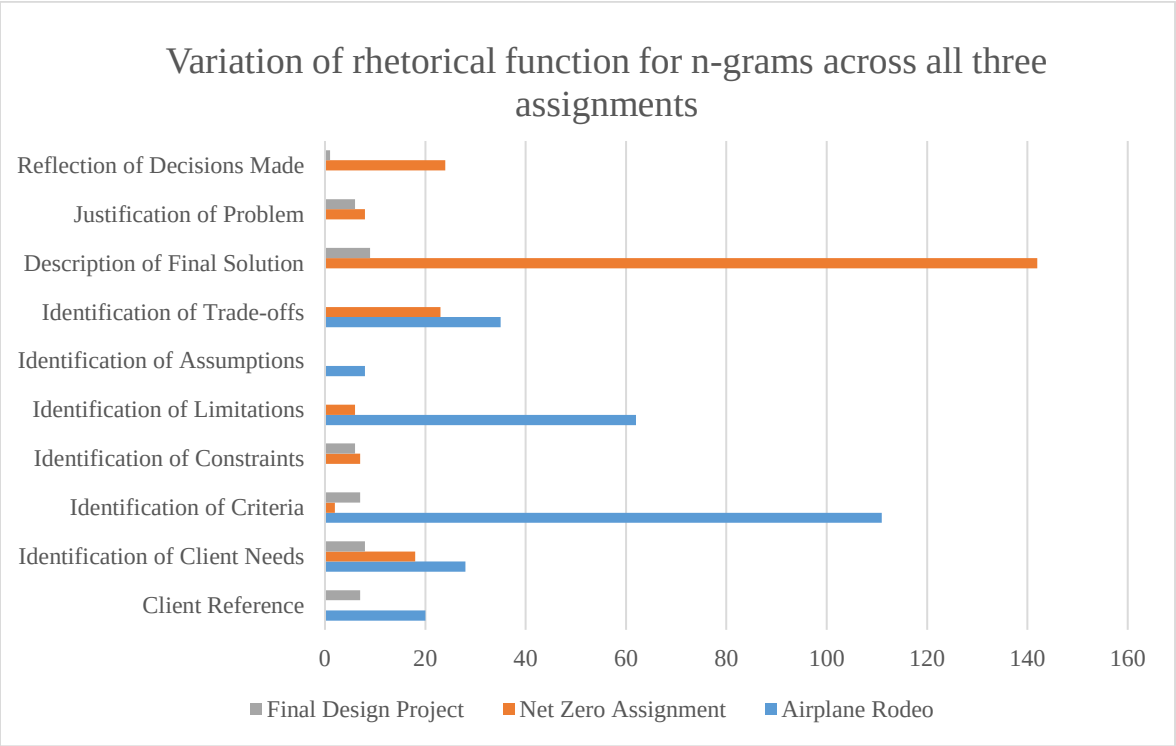

Figure 6.1 Rhetorical Function for N-grams Across all Three Assignments

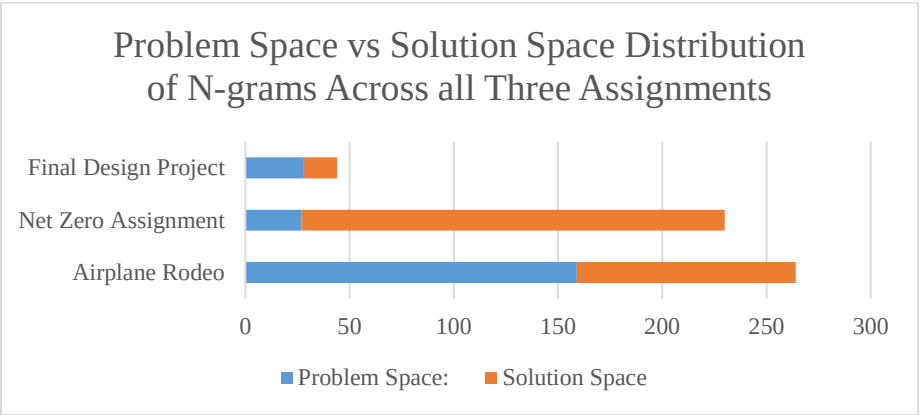

Figure 6.2 Problem space vs Solution space Distribution of N-grams Across all Three Assignments

A key finding in chapter 5 reveals that many of the linguistic and structural decisions that students made in their writing reflect a strong interaction with the pedagogical materials. For starters, all n-grams coded were identified in the pedagogical materials either as content words or suggested syntax structure for writing problem statements. Additionally, students' consistent uses of appositives, possessive adjectives, np+v constructions, and *that*-clauses reflect linguistic features present in the pedagogical materials. Further, students' texts were often observed as being directly copied/pasted from the pedagogical materials, particularly when students were attempting to address problem specifications (e.g., criteria and constraints). These patterns reflect that students are possibly attempting to model the genre conventions expected of them, but they are not necessarily internalizing neither the new procedural and conceptual knowledge they are learning, nor the genre knowledge and language knowledge needed to demonstrate their acquisition of discipline-specific knowledge.

6.3 Implications for an ESP and genre analysis approach for FYE

A potential pitfall for building genre knowledge is that students may be unsuccessfully exposed to and compared to professional writers (Flowerdew, 2000; Marshall, 1991), which they are not likely able to replicate. Rather than suggesting that students are exposed to texts that represent industry and practitioner writing, which is often very different from the writing that undergraduate students produce – in a myriad of ways (see Conrad, 2017, 2018; Conrad, Pfeiffer, & Lamb, 2018) – FYE students would likely benefit from exposure to other "good" apprenticeship genre examples that represent undergraduate writing performance that meets the standards of ABET and FYE (see Jacoby, Leech, & Holten, 1995). Big pedagogical problems such as this require interdisciplinary approaches; building collaborative and interdisciplinary relationships with scholars in applied linguistics and writing studies would help facilitate the

collection of students' texts (much like I was able to do for this dissertation) and pedagogical materials where invested parties may be able to analyze and assess both L1 and L2 students' writing and suggest feasible curricular changes or additions. For instance, Conrad, Pfeiffer, and Lamb (2018) have demonstrated that such research is not only feasible but effective for both Civil Engineering faculty and students. Because engineering at the industry level has become very multilingual and interdisciplinary, engineering programs would also benefit from engaging in cross-disciplinary conversations about best practices for teaching multilingual, multiethnic students.

The data collected for this dissertation demonstrated that FYE students may be developing some knowledge of genres, particularly those genres that are focused on identifying problems and solutions; however, students may benefit from a more explicit, practice-based approach to writing in engineering where students are able to ask questions about genre conventions and vocabulary with discipline-specific meanings. One approach might be to have students analyze the differences and similarities (both in terms of language and genre and content and procedures) between problem spaces and solutions spaces and their potential audiences in "good" student examples. In this way, students can more explicitly gain the form knowledge and language knowledge in tandem with procedural knowledge and conceptual knowledge.

6.4 Limitations and Future Directions

Although this dissertation begins to unpack what it means to communicate effectively in FYE, it does not tell us how students engage with and understand the pedagogical materials and the writing process. The next logical step for this research would be to interview students. It would be helpful to ask students about their writing choices, how they understand and engage with language with discipline-specific meanings, the process of collaboratively writing (testing FYE

faculty's assumptions of when a text has switched writers). In addition to interviewing students, examining students' linguistic choices more closely, especially in relationship to students' language background, is another logical step. For example, students' uses of *that*-clauses, appositives, modals that indicate permission/ability and volition/prediction, and and np+v constructions would be worth unpacking and analyzing for linguistic features and syntactic structures that faculty find more communicatively effective. Compiling a corpus of professional genres with a problem statement component would provide further insight into the function and purposes of teaching problem statements in FYE and the potential transfer between academic writing and industry writing, especially if texts from more advanced students (juniors and seniors) were collected.

Perhaps the most prominent limitation of this research is that it does not account for students' perspectives of the writing process and effective communication in FYE. Understanding students' writing and language backgrounds would provide a more descriptive picture of the texts that were analyzed for this research. Without this perspective, large portions of the story are missing, leaving greater room for speculation. Additionally, interviewing more FYE faculty would have provided a more representative understanding of writing and effective communication for the program. Lastly, industry perspective plays a central role in much of the scholarship on writing in engineering; interviews with practicing engineers

Finally, as a second language writing scholar this research has provided me with a wealth of opportunities to explore and develop interdisciplinary collaborations for both teaching and research purposes. This research has allowed me to more thoroughly explore genre theory and ESP frameworks for researching and teaching effective communication and discipline-specific genre conventions for undergraduate writers.

APPENDIX A. PROBLEM STATEMENT CODING RUBRIC FOR MOVE/STEP ANALYSIS

The first step in identifying the key rhetorical steps of a problem statement is identifying the problem statement itself, a key generic move of the three genres analyzed for this study. The following is a description of a problem statement:

Problem Statement (PS):

- a clear, concise, and complete description of a problem to be solved.
- the explanation of the problem is based on synthesis of *client, user, and other stakeholder needs.*
- the problem statement includes key specifications (in terms of criteria and constrains) that address what the client wants and what the user needs.
- is a description of the need and the goals to be met, including a summary of problem constraints & criteria and assumptions made.
- should not have a direct reference to a solution.
- typically located at the beginning of a larger text (i.e., in the introduction or executive summary of a technical brief or design report).
- generally begins with a reference to a client, user, or stakeholder and an identification of a need;
- generally ends with an identification of assumptions and limitations.

Each of the following *steps* below should occur within a problem statement. Below is a description of each step with examples.

Client Reference (CR): a direct reference to the client, user, or stakeholder invested in the design solution.

- CR may occur at any place in a sentence or paragraph. Generally, however, CR is mentioned in the introduction to the document (where the problem statement is located), and the first step associated with the problem statement.

Active Voice (NP + v) (generally appositives)

- Occurring at the beginning of a sentence:
    - The + noun-subject + present tense verb:
        - *The client, Amelia Wright, requires*
    - Our + noun-subject + present tense verb:
        - *Our client, Amelia Wright, requires*
- Occurring in the middle of a sentence:
    - Contextual description + client name + present tense verb:
        - *Due to current rigid and non-data based maintenance schedules Kimberly-Clark wants*
- Client's name at the beginning of the sentence:
    - Noun-subject + present perfect verb
        - *Purdue has asked us to design a building…*

Passive Voice

- Can occur at the beginning or in the middle of a sentence:
    - Noun-subject + passive+ verb phrase + direct object + that-*clause*
        - *Our team was asked to design an apartment building for Purdue Housing that could comfortably…*

When a Stakeholder:

- ***The needs of the businesses*** *are to implement a new model to their restrooms to allow for them to stay more stocked while reducing the waste of unused product and keeping a high level of cleanliness because statistically it reflects poorly on businesses that have dirty and poorly stocked restrooms. (Schwartz, 2016)*
- ***The needs of the other stakeholders****, which include professors, students, and visiting guests, are defined by the resource efficiency and production satisfaction criteria in the second paragraph.*

When a User:

- *The clients were the Tumaini Innovation Center, and* ***the direct users were the students at the Tumaini Innovation Center.***

Client Needs (CN): directly following CR is CN where the design team acknowledges what the client, stakeholders, and/or users need. Generally this need is problem-based. CN generally occurs directly after CR within the same sentence as CR and with a present-tense verb.

- When embedded in the same sentence as the CR following a present-tense verb. For example:
    - *Due to current rigid and non-data based maintenance schedules Kimberly-Clark* ***wants*** ***to have a new scheduling system developed*** *that allows customers to optimize a weekly maintenance schedule for an entire building****.***
    - *The client, Amelia Wright,* ***requires*** ***a protocol that provides an accurate and unbiased way of judging the competition for the Best Floater and Most Accurate plane.***

- *The client, Purdue University, **wants** **a net zero energy apartment building** that is capable of housing 16 students.*
- *the clients, who are the founders of a start-up that make ecologically sustainable products, **require** **a product that uses only materials** that are recycled, reused, or repurposed.*
- ***The client, Jessica Sherek from Kimberly Clark Professional**, **requires** an evidence-based model to provide a weekly schedule of bathroom maintenance for an engineering building, but that can be modifiable to apply to other buildings. **The customers of KCP** **need** to decrease the cost of bathroom products, which can be done by minimizing the amount of wasted, unused products. **The users of the bathroom** **need** a clean environment in which products are readily available at any point during the day.*

- At times, CN has an implied client.
  - ***The project involved the design of a net zero energy campus residence apartment building -** a building in which the total amount of energy used by it on an annual basis is roughly equal to the amount of renewable energy created on the site of the building - under the cost constraint of 350,000 USD without compromising on the comfort of the resident students and curb appeal.*
- Occasionally, the need may be stated as a goal or an objective the client has.
  - ***The goal of Tumaini's** 'Upcycling Design Challenge' **is to develop a product** out of recycled, reused, or repurposed materials that educates engineering concepts to secondary-level students.*

Justification of the Project/Problem: JP refers to when the writers attempt to justify the purpose of the needs or problems being addressed. This step can occur at any time in the document. In the first example, the justification is a step after the criteria and constraints.

- *More specifically, the building must produce more than or equal to as much energy as it consumes in one calendar year, it must cost fewer than $350,000 to construct, and it must be both visually attractive and comfortable to live in**. If the design consumes a net zero energy, it will have less of a negative impact on the environment.*** *So long as the apartment building costs less than $350,000, the benefit to the university, its students, and the environment will be worth the initial investment.*
- *Kenya is an example of a developing country that recognize the need for improvement in the education system, and is seeking to do so. The Tumaini Innovation center in particular. Tumaini is a school in Eldoret, Kenya that seeks to improve education in its area by educating children from the streets using interesting and engaging projects. To aid their education of students, the Tumaini Innovation Center requires a low-cost project/curriculum that utilizes recycled materials and will provide the students with a more in-depth education on an engineering topic relating to solar energy, topics they have/are learning about, and/or are interested in learning about. This would provide the students a better, hands-on and engaging education that will spark their curiosity.*
- ***This problem is important to solve*** *because students can spend up to 40 minutes walking from class to class on larger campuses and, if it were raining during this time, the students would get drenched. This would cause lower attendance in classes and, for the students who did go to class, being soaked would cause the students to have less concentration on the lessons being taught.*

- *The exact problem we addressed in the project is summarized in our problem statement: The client, a leading moving company in the Unites States, is requesting a team of engineers to develop, maintain, and manage a new line of ecologically sustainable, upcycled products that facilitate the college move-in process for freshmen.* ***This problem is important to solve because*** *throughout the move-in process all over the country, there is a large need for objects that aid in dorm organization, storage, decoration, and other necessities. Items which make move-in easier would greatly reduce the stress that freshmen students undergo while moving in*

Purpose of Client Needs (PCN): PCN generally follows CR and CN and provides additional information about the problem.

- May be embedded within the same sentence as CI and CN (*that*-clause)
    - *Due to current rigid and non-data based maintenance schedules Kimberly-Clark wants to have a new scheduling system developed* ***that*** ***allows customers to optimize a weekly maintenance schedule for an entire building.***
    - *The client Kimberly Clark wants to enable their customers to use their products efficiently* ***so that*** ***they can reduce number of touchpoints, interactions as needed, and product waste for saving cost and cleanliness for bathroom****.*

Identification of Criteria (IC): A standard of judgement, or rule or principle for evaluating something, such as potential design solutions. Criteria help you choose between options. Criteria should be clear and measurable. IC generally follows CR, CN, and PNC. In most cases, IC is identified by the use of the word “criteria” such as:

- *…****the criteria*** *for success in this scoring system is getting the maximum amount of points to determine a winner for each TCAA award.*

- *…**the criteria** for success of this method is average distance from target and average flight velocity respectively.*
- *…focus on 3 **criteria**—energy efficiency (consume no net energy year-round), cost (under $425,000) and desirability (including factors like number of trees, ratio of windows to walls, etc.)*
- ***The criteria** are that the house must be energy efficient meaning that the net energy over the year must be equal to or less than zero. The house must be attractive and the cost must be under $425,000.*
- *The **criteria** for this problem are that **the product must be** able to be created simply and cheaply so a working prototype can be manufactured and that it must adequately protect…*

Identification of Constraints (IC2): specifications that limit how a problem can be solved. In engineering design, constraints are used to evaluate potential design solutions. They are criteria that must be met. Constraints include budget, time, human resources, dimensions, etc.

- *For profitable, the product **must be able to** be sold for more money than it costs to make.*
- ***The requirements** include that at least 50% of the total materials used in the solution be recycled, reused, or repurposed from inside the camp, the materials used **need to be** readily available, and the solution should be designed with a level of safety in mind.*

Identification of Limitations (IL)

Limitations are further explanation of constraints and lead to trade-offs made.

- ***The limitations of our procedure** are the quality of the measurements and consistency of the pilots.*

- ***A limitation of the building is the budget****, since we had a limited budget we did not have the money to be able to have bigger building which sacrifices desirability.* → (It is possible to also view this as ITO)
- *Our design* ***was limited by possible*** *expenses and the need for a net-zero energy building.*

Identification of Assumptions

- ***Assumptions*** *that were made are that the materials will be readily available and that the product will be able to be mass produced.*
- *It is* ***assumed*** *that it is important for the users of the bathroom to have a good experience. It is also assumed that, in order to have a good experience in the bathroom, users must have access to product and the bathroom must be clean.*

Identification of Trade-offs (ITO): ITO generally follows the problem statement after the authors discuss criteria and constraints. ITO may occur before or after IL and IA. Typical language that associated with ITO can be categorized as cause/effect with some degree of the following:

- Because this then this
- Restrictions
- Traded for
- A trade off we had to make
- In order to x we had to do y
- At cost/expense of
- Made a compromise
    a) *"<u>Because</u> of the constraints given, the window to wall ratio <u>had to be relatively small</u> so that the construction cost remained under $350,000. Also, the size of the*

house (316 m2 for two floors) was somewhat restricted due to cost constraints: the comfort of residents and an attractive exterior was traded for cost efficiency. However, after the analysis of all the models using the weighted decision matrix, this model was chosen to be the best one as it fulfilled all the criteria without breaking any constraints."

b) *Trade-offs that were made in order to achieve an attainable solution include 3 throwers will throw each plane 3 times. The 3 throwers will be the same each time. This is fair since it is the same three people every time but since they will get tired as time goes on they will get tired and this could bring human error.*

Description of Solution for Final Design (DSFD): DSFD generally speaks to when writers begin summarizing the description of their final solution and is connected to their criteria and constraints.

Examples:

- *The designed apartment building has curb appeal based on the number of trees it has, its window to wall ratio and its symmetry. Since the proposed building has six trees, this would satisfy the curb appeal because no trees is considered to be undesirable ("Top 5 Landscaping Tips."). Also, the window to wall ratio is 0. 184 which means that there are a lot of windows in juxtaposition to walls and the greater the number of windows, the greater the curb appeal. The building is also symmetrical making it have a greater curb appeal.*
- *The biggest impact on cost is done by the walls. They cost 29.65% of the building, which is about $101,045. The foundation also has a big impact on the cost. It costs about $90,719, or 26.62% of the total cost. The roof, solar panels, and windows also impact the*

cost, but not so drastically. They contribute to 13.03%, 11.69%, and 10.34% of the total cost, respectively.

- *Our product meets the needs of the client as it will be made from used/upcycled shingles.*
- *Cost was an obvious factor because the solution idea that was the most cost-effective would gain favor over more expensive solution ideas. Relevancy meant that our solution ideas fit the needs of the Tumaini Innovation Center and those of the surrounding community.*

Reflection of Decisions Made (REFL): REFL is a code that is most likely to occur in the second and final assignments and most frequently takes place towards the end of the text; however, it is possible to observe reflective-like language and strategies anywhere in the document. The authors use reflective language, often modals, personal pronouns, including:

- Should
- Could
- We
- Our

REFL also speaks to where writers begin to discuss lessons learned and difficulties they encountered during the design process. REFL is different from DSFD in that the tone (as indicated by the language) slightly changes from a more formal, matter of fact with emphasis on data, to more informal "this is what we learned." There will likely be references to the solution and the problem, but it goes beyond a summary of data to explanation of choices made and possible future iterations.

- *The math behind our model here ended up actually being very accurate which pushed us to encourage it; however, we could not truly incorporate this math into our computer*

program. Ultimately, we chose to use our computer program due to its ease of use for the janitors as well as the adaptability of this model. We decided to trade of the preciseness of our second choice to instead obtain our current model, which is easily usable and adaptable to more bathrooms on campus. We concluded this fulfills the needs of the client more sufficiently.

- *Potential improvements include being able to improve desirability while getting an energy efficient building as well, we could have a more complex design instead of just making a rectangle. Limitations were not difficult when each person had only 2 criteria to fulfill, but putting all 3, desirability, energy and cost efficiency, made it more difficult to include everything. We learned what affected energy gain in a building design, and how to obtain the best net zero energy building.*

Inaccurate Use of Term(s) (IUT) – which results in unclear meaning.

- *Trade-offs that were made in order to achieve an attainable solution include finding the best time/distance of the racers in determining overall performance and using trigonometry to find the exact distance to target so we can compare the racer's distance to it.*
- *Limitations and/or trade-ffs that were made in order to achieve an attainable solution include the assumption that all three pilots were consistent in there throws for all three planes and that the wind was negligible during the competition.*
- *Limitations and/or trade-offs that were made in order to achieve an attainable solution include that we couldn't find an exact number for how to weigh the distance versus the angle in the calculation for most accurate so we had to choose an arbitrary number that would still give us a value that calculated a winner. Additionally, we weren't able to use*

every single piece of data to determine a winner, but we did choose the most relevant data to the competition that we were calculating.

- *Trade-offs that were made in order to achieve an attainable solution include calculating the plane's distance from the center line through a trigonometric function because that measurement is not given.* → FUNCTIONS AS AN ASSUMPTION, NOT TRADE-OFF

NA: Incomplete – when students leave the original document's instructions to fill in the blank and do not write a response.

APPENDIX B. INTERVIEW QUESTIONS FOR DR. RODRIGUEZ

1. Can you define what a *problem statement* is?
2. Can you explain the importance or significance of teaching *problem statements* in FYE?
3. What information do you expect to see in a *problem statement*?
    a) Where do these expectations come from?
4. In my analyses, I noticed seven different "moves" that appear to be expected in problem statements:
    a) A direct reference to a client
    b) An identification of the client's needs
    c) An identification of criteria
    d) An identification of constraints
    e) An identification of limitations
    f) An identification of assumptions
    g) An identification of trade-offs
5. Are these accurate?
    a) Can you briefly define these (for a non-expert)?
6. Do your expectations for what information you expect to see in a problem statement change/alter in anyway depending on the assignment? (for example, is there a difference between the problem statement in the Airplane Tech Brief compared to the Energy Tech Report?) (use data to provide examples)
7. What difficulties do students most often exhibit when they are writing problem statements? Or what are some common issues you come across when teaching problems statements, particularly as it relates to students' language choices? (use data to provide examples)

8. Do you notice any significant differences in writing strategies between students who identify as L1 and students who identify as L2?
9. When I was analyzing the pedagogical materials, I noticed that the first assignment, the airplane tech brief, has specific language students are supposed to use and then they fill in the blanks. Is the language in this assignment expected to be used by students in future problem statements? (show example).
10. ABET lists "an ability to communicate effectively" as a student learning outcome and this SLO is also listed on the ENGR 131 syllabus. Unfortunately, ABET does not define what it means to "communicate effectively." Can you tell me what it means to communicate effectively in first year engineering (from your perspective of course)? How does this translate to teaching effective writing strategies in FYE?
    a) Are there specific strategies in writing that you believe FYE students should learn and use?
11. I'd like to have you look at few examples I've selected from the data set and select a few that you believe "Communicate effectively" and a few that you believe do not, and briefly talk me through why that is.
    a) Is there any language here that you find particularly in/effective?
    b) In what ways, specifically related to language, do you think this document might be improved?

APPENDIX C. INTERVIEW QUESTIONS FOR DR. REIS

1. Can you identify the problem statement in each of these documents?
    a) What makes this the problem statement?
2. Can you rate this in terms of effectiveness (an ability to communicate effectively)?
3. Can you describe your decisions (what makes this text more effective than the other)?
4. Is there any language here that you find particularly in/effective?
5. In what ways, specifically related to language, do you think this document might be improved?
6. When I was analyzing the pedagogical materials, I noticed that the first assignment, the airplane tech brief, has specific language students are supposed to use and then they fill in the blanks. Is the language in this assignment expected to be used by students in future problem statements? (show example). Why or why not?
7. Are these the 8 steps you expect to see in a problem statement:
    a) A direct reference to a client
    b) An identification of the client's needs
    c) An identification of the purpose of the clients' needs
    d) An identification of criteria
    e) An identification of constraints
    f) An identification of limitations
    g) An identification of assumptions
    h) An identification of trade-offs
8. Can you define these?
9. Can you identify them in the texts here?

10. Can you define what a problem statement is?

11. Can you explain the importance or significance of teaching *problem statements* in FYE?

12. What information do you expect to see in a *problem statement*?

    a) Where do these expectations come from?

13. Do you notice any significant differences in writing strategies between students who identify as L1 and students who identify as L2?

14. What difficulties do students most often exhibit when they are writing problem statements? Or what are some common issues you come across when teaching problems statements, particularly as it relates to students' language choices? (use data to provide examples)

15. ABET lists "an ability to communicate effectively" as a student learning outcome and this SLO is also listed on the ENGR 131 syllabus. Unfortunately, ABET does not define what it means to "communicate effectively." Can you tell me what it means to communicate effectively in first year engineering (from your perspective of course)? How does this translate to teaching effective writing strategies in FYE?

16. Are there specific strategies in writing that you believe FYE students should learn and use?

APPENDIX D. INTERVIEW QUESTIONS FOR DR. ROBINS

Background:

1. How long have you been teaching at Purdue?
2. Do you have experience in industry?
3. How does this inform your approach to teaching writing?
4. What are some goals you have for students when teaching writing?
5. ABET lists "an ability to communicate effectively" as a student learning outcome and this SLO is also listed on the ENGR 131 syllabus. Unfortunately, ABET does not define what it means to "communicate effectively." Can you tell me what it means to communicate effectively in first year engineering (from your perspective of course)? How does this translate to teaching effective writing strategies in FYE?
    a. Are there specific strategies in writing that you believe FYE students should learn and use?

Problem statements & Writing:

1. Generally speaking, what is the goal with problem statements?
    a. What learning objectives do problem statements achieve?
    b. Will students continue to write problem statements even after their FYE experience?
2. Are problem statements common in industry?
3. What information are students expected to include in a problem statement?
4. In my analyses, I identified 8 steps that appear to be associated with problem statements:
    a. A direct reference to a client
    b. An identification of the client's needs
    c. An identification of the purpose of the client's needs

   d. An identification of criteria
   e. An identification of constraints
   f. An identification of limitations
   g. An identification of assumptions
   h. An identification of trade-offs

5. Can you define these?
6. Can you tell me the difference between criteria and constraints?
7. Can you tell me the difference between a limitation and a constraint?
8. Can you tell me the difference between criteria and limitations?
9. Can you tell me the difference between a limitation and a trade-off?
   a. Is OK for students to use these two terms interchangeably?
10. What makes a problem statement effective vs ineffective?
11. What difficulties do students most often exhibit when they are writing problem statements? Or what are some common issues you come across when teaching problems statements, particularly as it relates to students' language choices? (use data to provide examples)
12. Do you notice any significant differences in writing strategies between students who identify as L1 and students who identify as L2?

Texts:

I have some examples here from data I have coded – I'd like you to talk me through them.

Potential questions:

1. Can you identify the problem statement for me?
2. What language signals where the problem statement ends and begins?
3. Is there any language here you find particularly in/effective?

4. Can you identify which of these examples (for each assignment) is most effective?
    a. Can you describe your decision?

REFERENCES

Abel, K. D., & Fernandez, A. A. (2005). ABET accreditation of undergraduate engineering management programs: established versus new programs—The similarities and differences. *Engineering Management Journal*, *17*(1), 3-8.

Bakhtin, M. M. (2010). *Speech genres and other late essays*. University of Texas Press.

Bamberg, B. (1983). What makes a text coherent?. *College composition and communication*, *34*(4), 417-429.

Bawarshi, A. S., & Reiff, M. J. (2010). *Genre: An introduction to history, theory, research, and pedagogy* (p. 4). West Lafayette, IN: Parlor Press.

Bazerman, C. (1988). *Shaping written knowledge: The genre and activity of the experimental article in science* (Vol. 356). Madison: University of Wisconsin Press.

Bazerman, C. (2009). *Traditions of writing research*. New York, NY ; Abingdon, Oxon: Routledge.

Beaufort, A. (2012, September). College writing and beyond: Five years later. In *Composition Forum* (Vol. 26, pp. 1-13).

Beaufort, A. (2008). *College writing and beyond: A new framework for university writing instruction*. University Press of Colorado.

Berthouex, P. M. (1996). Honing the writing skills of engineers. *Journal of Professional Issues in Engineering Education and Practice*, *122*(3), 107-110.

Bergquist, M., & Ljungberg, J. (1999, January). Genres in action: Negotiating genres in practice. In *Systems Sciences, 1999. HICSS-32. Proceedings of the 32nd Annual Hawaii International Conference on* (pp. 11-pp). IEEE.

Berkenkotter, C., & Huckin, T. N. (2016). *Genre knowledge in disciplinary communication: Cognition/culture/power*. Routledge.

Bhatia, V. K. (1991). A genre-based approach to ESP materials. World Englishes, 10(2), 153-166.

Bhatia, V. (2004). *Worlds of written discourse: A genre-based view*. A&C Black.

Biber, D. (2009). A corpus-driven approach to formulaic language in English. *International journal of corpus linguistics*, *14*(3), 275-311.

Biber, D., & Barbieri, F. (2007). Lexical bundles in university spoken and written registers. *English for specific purposes*, *26*(3), 263-286.

Biber, D., Conrad, S., & Leech, G. (2002). *Longman student grammar of spoken and written English.* Essex: Longman

Biber, D., Conrad, S., & Cortes, V. (2004). If you look at…: Lexical bundles in university teaching and textbooks. *Applied linguistics*, *25*(3), 371-405.

Braithwaite, C. A. (1984). Towards a conceptualization of 'speech community'. In *Minnesota regional conference on language and linguistics* (pp. 13-29).

Bruce, I. (2009). Results sections in sociology and organic chemistry articles: A genre analysis. *English for Specific Purposes*, *28*(2), 105-124.

Brunhaver, S., Korte, R., Lande, M., & Sheppard, S. (2010, June). Supports and barriers that recent engineering graduates experience in the workplace. In *Proceedings of the American Society for Engineering Education Annual Conference, Louisville, KY*.

Buswell, N. T., Jesiek, B. K., Troy, C. D., Essig, R. R., & Boyd, J. (2019). Engineering Instructors on Writing: Perceptions, Practices, and Needs. *IEEE Transactions on Professional Communication*, *62*(1), 55-74.

Campbell, K. K., & Jamieson, K. H. (1978). Form and genre: Shaping rhetorical action.

Carter, M., Ferzli, M., & Wiebe, E. N. (2007). Writing to learn by learning to write in the disciplines. *Journal of Business and Technical Communication*, *21*(3), 278-302.

Christie, F., & Martin, J. R. (2005). *Genre and institutions: Social processes in the workplace and school*. A&C Black.

Chen, Y. H., & Baker, P. (2010). Lexical bundles in L1 and L2 academic writing. *Language Learning & Technology*, *14*(2), 30-49.

Cheng, A. (2006). Understanding learners and learning in ESP genre-based writing instruction. *English for Specific Purposes*, *25*(1), 76-89.

Cheng, A. (2008). Analyzing genre exemplars in preparation for writing: The case of an L2 graduate student in the ESP genre-based instructional framework of academic literacy. *Applied linguistics*, *29*(1), 50-71.

Cheng, W., Greaves, C., & Warren, M. (2006). From n-gram to skipgram to concgram. *International journal of corpus linguistics*, *11*(4), 411-433.

Christie, F., & Martin, J. R. (2005). *Genre and institutions: Social processes in the workplace and school*. A&C Black.

Chung, T. M., & Nation, P. (2004). Identifying technical vocabulary. *System*, *32*(2), 251-263.

Clark, R., & Ivanič, R. (1997). Critical discourse analysis and educational change. In *Encyclopedia of language and education* (pp. 217-227). Springer, Dordrecht.

Conklin, K., & Schmitt, N. (2008). Formulaic sequences: Are they processed more quickly than nonformulaic language by native and nonnative speakers?. *Applied linguistics*, *29*(1), 72-89.

Conrad, S. (2017). A comparison of practitioner and student writing in civil engineering. *Journal of Engineering Education*, *106*(2), 191-217.

Conrad, S. (2018). The use of passives and impersonal style in civil engineering writing. *Journal of Business and Technical Communication*, *32*(1), 38-76.

Conrad, S., Pfeiffer, T.J., Lamb, K. (2018, June). Board 27: Improving Student Writing with Research-based Instruction: Results from the Civil Engineering Writing Project. In *2018 ASEE Annual Conference & Exposition*.

Cortes, V. (2004). Lexical bundles in published and student disciplinary writing: Examples from history and biology. *English for specific purposes*, *23*(4), 397-423.

Cortes, V. (2006). Teaching lexical bundles in the disciplines: An example from a writing intensive history class. *Linguistics and Education*, *17*(4), 391-406.

Cotos, E., Huffman, S., & Link, S. (2017). A move/step model for methods sections: Demonstrating rigour and credibility. *English for Specific Purposes*, *46*, 90-106.

Crossley, S. A., Salsbury, T., McNamara, D. S., & Jarvis, S. (2011). Predicting lexical proficiency in language learner texts using computational indices. *Language Testing*, *28*(4), 561-580.

Daller, H., van Hout, R., & Treffers-Daller, J. (2003). Lexical richness in the spontaneous speech of bilinguals. *Applied Linguistics*, *24*(2), 197–222.

Dannels, D. (2002). Communication Across the Curriculum and in the Disciplines: Speaking in Engineering. *Communication Education*, *51*(3), 254-268.

Devitt, A. (2007). Transferability and genres. In C. Keller & C. Weisser (Eds.), *Locations of composition* (pp. 215-228). New York, NY: State University of New York Press.

Ding, H. (2007). Genre analysis of personal statements: Analysis of moves in application essays to medical and dental schools. *English for Specific Purposes*, *26*(3), 368-392.

Donnell, J. A., Aller, B. M., Alley, M., & Kedrowicz, A. A. (2011). Why industry says that engineering graduates have poor communication skills: What the literature says. In *ASEE Annual Conference and Exposition, Conference Proceedings*.

dos Santos, V. P. (2002). Genre analysis of business letters of negotiation. *English for specific purposes*, *21*(2), 167-199.

Driscoll, D. L., & Wells, J. (2012). Beyond Knowledge and Skills: Writing Transfer and the Role of Student Dispositions. In *Composition Forum* (Vol. 26). Association of Teachers of Advanced Composition.

Dressen-Hammouda, D. (2012). Ethnographic approaches in ESP. In B. Paltridge & S. Starfield (Eds.), *The Handbook of English for Specific Purposes*, (pp. 501-518). Wiley.

Dunsmore, K., Turns, J., & Yellin, J. M. (2011). Looking toward the real world: Student conceptions of engineering. *Journal of Engineering Education*, *100*(2), 329-348.

Durrant, P., & Mathews-Aydınlı, J. (2011). A function-first approach to identifying formulaic language in academic writing. *English for Specific Purposes*, *30*(1), 58-72.

Easterbrook, S., & Al-Rawas, A. (1996). Communication Problems in Requirements Engineering: A Field Study - NASA-IVV-96-002 - NASA-CR-203071. *Proceedings of the First Westminster Conference on Professional Awareness in Software Engineering|Professional Awareness in Software Engineering*, Proceedings of the First Westminster Conference on Professional Awareness in Software Engineering|Professional Awareness in Software Engineering; 1-2 Feb. 1996; London; United Kingdom.

Ellis, R. (1995). Modified oral input and the acquisition of word meanings. *Applied Linguistics, 16*, 409-435.

Ellis, N. C., Simpson-Vlach, R. I. T. A., & Maynard, C. (2008). Formulaic language in native and second language speakers: Psycholinguistics, corpus linguistics, and TESOL. *Tesol Quarterly*, *42*(3), 375-396.

Elton, L. (2010). Academic writing and tacit knowledge. *Teaching in higher education*, *15*(2), 151-160.

Eriksson, A. (2012). Pedagogical perspectives on bundles: teaching bundles to doctoral students of biochemistry. In J. Thomas, & A. Boulton (Eds.), Input, process and products. Developments in teaching and language corpora (pp. 195-211). Brno, Czech Republic: Masaryk University Press.

Flowerdew, J. (1993). An educational, or process, approach to the teaching of professional genres. *ELT journal*, *47*(4), 305-316.

Flowerdew, L. (2000). Using a genre-based framework to teach organizational structure in academic writing. *ELT journal*, *54*(4), 369-378.

Flowerdew, J. (2000). Discourse Community, Legitimate Peripheral Participation, and the Nonnative-English-Speaking Scholar. *TESOL Quarterly*, *34*(1), 127-50.

Flowerdew. J. (2011 Reconciling contrasting approaches to genre analysis: The whole can equal more than the sum of the parts. In D. Belcher, A.M. Johns, & Brian Paltridge (Eds.), *New directions in research for English for specific purposes.* Ann Arbor, MI: University of Michigan Press.

Flowerdew, J. (2011). Action, content and identity in applied genre analysis for ESP. *Language Teaching*, *44*(4), 516-528.

Ford, J. D. (2004). Knowledge transfer across disciplines: Tracking rhetorical strategies from a technical communication classroom to an engineering classroom. *IEEE Transactions on Professional Communication*, *47*(4), 301-315.

Ford, J. D., & Riley, L. A. (2003). Integrating communication and engineering education: A look at curricula, courses, and support systems. *Journal of Engineering Education*, *92*(4), 325-328.

Ford, J., & Teare, S. (2006). The right answer is communication when capstone engineering courses drive the questions. *Journal of STEM education*, *7*(3).

Freedman, A., & Medway, P. (2003). *Genre in the new rhetoric*. Routledge.

Gassman, S. L., Maher, M. A., & Timmerman, B. E. (2013). Supporting students' disciplinary writing in engineering education. *International Journal of Engineering Education*, *29*(5), 1270-1280.

Gere, A. R., Aull, L., Escudero, M. D. P., Lancaster, Z., & Lei, E. V. (2013). Local assessment: Using genre analysis to validate directed self-placement. *College Composition and Communication*, 605-633.

Gilbert, G. N., Gilbert, N., & Mulkay, M. (1984). *Opening Pandora's box: A sociological analysis of scientists' discourse*. New York: Cambridge University Press,

Gilmore, A., & Millar, N. (2018). The language of civil engineering research articles: A corpus-based approach. *English for Specific Purposes*, *51*, 1-17.

Grabe, W., & Kaplan, R. (1996). *Theory and practice of writing: An applied linguistic perspective* (Applied linguistics and language study). London ; New York: Longman.

Gray, B. (2015). *Linguistic variation in research articles*. Amsterdam.

Gruber, S., Larson, D., Scott, D., & Neville, M. (1999). Writing4Practice in engineering courses: Implementation and assessment approaches. *Technical Communication Quarterly*, *8*(4), 419-440.

Harrington, S., Malencyzk, R., Peckham, I., Rhodes, K., & Yancey, K. B. (2001). WPA outcomes statement for first-year composition. *College English*, *63*(3), 321-325.

Henry, A., & Roseberry, R. L. (2001). A narrow-angled corpus analysis of moves and strategies of the genre:'Letter of Application'. *English for Specific Purposes*, *20*(2), 153-167.

Hernon, P., & Schwartz, C. (2007). What is a problem statement?. *Library and Information Science Research*, *3*(29), 307-309.

Hirsch, P. L., Casler, J. C., Anderson, J. D., Smith, H. B., Birol, G., Troy, J., & Yalvac, B. (2005). *ASEE Annual Conference and Exposition, Conference Proceedings*, 5827-5846.

Hirsch, P., Smith, H. D., Birol, G., Yalvac, B., Casler, J., Anderson, J., & Troy, J. (2005). Establishing school-wide standards for engineering writing: A data driven approach.

Holmes, R. (1997). Genre analysis, and the social sciences: An investigation of the structure of research article discussion sections in three disciplines. *English for specific Purposes*, *16*(4), 321-337.

Hopkins, A., & Dudley-Evans, T. (1988). A genre-based investigation of the discussion sections in articles and dissertations. *English for specific purposes*, *7*(2), 113-121.

Howarth, P. (1998). Phraseology and second language proficiency. *Applied linguistics*, *19*(1), 24-44.

Howard, S. K., Khosronejad, M., & Calvo, R. A. (2017). Exploring Engineering instructors' views about writing and online tools to support communication in Engineering. *European Journal of Engineering Education*, *42*(6), 875-889.

Hunston, S. (2010). How can a corpus be used to explore patterns. In O'Keeffe, A., & McCarthy, M. (Eds.), *The Routledge handbook of corpus linguistics* (1st ed., Routledge handbooks in applied linguistics). London; New York, NY: Routledge.

Huckin, T., Andrus, J., & Clary-Lemon, J. (2012). Critical discourse analysis and rhetoric and composition. *College Composition and Communication*, *64*(1), 107.

Hyland, K. (2003). Genre-based pedagogies: A social response to process. *Journal of second language writing*, *12*(1), 17-29.

Hyon, S. (1996). Genre in three traditions: Implications for ESL. *TESOL quarterly*, *30*(4), 693-722.

Jacoby, S., Leech, D., & Holten, C. (1995). A genre-based developmental writing course for under- graduate ESL science majors. In D. Belcher, & G. Braine, Academic writing in a second language: Essays on research and pedagogy. Norwood, NJ: Ablex.

Jamieson, K. M. (1975). Antecedent genre as rhetorical constraint. *Quarterly Journal of Speech*, *61*(4), 406-415.

Jesiek, B. K., Shen, Y., & Haller, Y. (2012). Cross-Cultural Competence: A Comparative Assessment of EngineeringStudents. *International Journal of Engineering Education*, *28*(1), 144.

Johns, A. M. (2001). *Genre in the classroom: Multiple perspectives*. Routledge.

Johns, T. F., & Dudley-Evans, A. (1980). An experiment in team-teaching of overseas postgraduate students of transportation and plant biology. *Team teaching in ESP*, 6-23.

Kassim, H., & Ali, F. (2010). English communicative events and skills needed at the workplace: Feedback from the industry. *English for Specific Purposes*, *29*(3), 168-182.

Kanoksilapatham, B. (2005). Rhetorical structure of biochemistry research articles. *English for specific purposes*, *24*(3), 269-292.

Kennedy, G. (2002). Variation in the distribution of modal verbs in the British National Corpus. *Using corpora to explore linguistic variation*, 73-90.

Klein, P. (1999). Reopening Inquiry into Cognitive Processes in Writing-To-Learn. *Educational Psychology Review*, *11*(3), 203-270.

Koen, P. A., & Kohli, P. (1998, June). ABET 2000: What are the most important criteria to the supervisors of new engineering undergraduates?. In *1998 Annual Conference* (pp. 3-64).

Kuhn, M. R., & Vaught-Alexander, K. (1994). Context for writing in engineering curriculum. *Journal of professional issues in engineering education and practice*, *120*(4), 392-400.

Lave, J., & Wenger, E. (1991). *Situated learning : Legitimate peripheral participation* (Learning in doing). Cambridge [England] ; New York: Cambridge University Press.

Leydens, J. A., & Schneider, J. (2009). Innovations in composition programs that educate engineers: Drivers, opportunities, and challenges. *Journal of Engineering Education*, *98*(3), 255-271.

Male, S. A., Bush, M. B., & Chapman, E. S. (2010). Perceptions of competency deficiencies in engineering graduates. *Australasian Journal of Engineering Education*, *16*(1), 55-68.

Marshall, S. (1991). A genre-based approach to the teaching of report-writing. *English for Specific Purposes*, *10*(1), 3-13.

Maswana, S., Kanamaru, T., & Tajino, A. (2015). Move analysis of research articles across five engineering fields: What they share and what they do not. *Ampersand*, *2*, 1-11.

Mayhew, M., Eljamal, M. B., Dey, E., & Pang, S. W. (2005). Outcomes assessment in international engineering education: creating a system to measure intercultural development. *age*, *10*, 1.

Mohamed, A. A., Radzuan, N. R. M., Kassim, H., & Ali, M. M. A. (2014). Conceptualizing English workplace communication needs of professional engineers: The challenges for English language tertiary educators. *Selangor Business Review (SBR)*, *1*(1).

Moslehifar, M. A., & Ibrahim, N. A. (2012). English language oral communication needs at the workplace: Feedback from human resource development (HRD) trainees. *Procedia-Social and Behavioral Sciences*, *66*, 529-536.

McCutchen, D. (1986). Domain knowledge and linguistic knowledge in the development of writing ability. *Journal of Memory and Language*, *25*(4), 431-444.

Miller, C. R. (1994). The cultural basis of genre. In A. Freedman & P. Medway (Eds.), *Genre and the new rhetoric* (pp. 67-78). London; Bristol, PA: Taylor & Francis.

Miller, C. R. (1984). Genre as social action. *Quarterly journal of speech*, *70*(2), 151-167.

Moore, T., & Morton, J. (2017). The myth of job readiness? Written communication, employability, and the ‘skills gap’in higher education. *Studies in Higher Education*, *42*(3), 591-609.

Nattinger, J. R., & DeCarrico, J. S. (1992). *Lexical phrases and language teaching*. Oxford University Press.

Neely, E., & Cortes, V. (2009). A little bit about: Analyzing and teaching lexical bundles in academic lectures. *Language Value*, *1*, 17-38.

Ning, Z. Y. (2008). A Genre-based Analysis of English Research Article Abstracts and the Linguistic Feature of Personal Pronouns for Financial Economics. *Online Submission*, *5*(7), 62-65.

Nobuyoshi, J., & Ellis, R. (1993). Focused communication tasks and second language acquisition. *ELT journal*, *47*(3), 203-210.

Nwogu, K. N. (1997). The medical research paper: Structure and functions. *English for specific purposes*, *16*(2), 119-138.

O'Neill, D. K. (2001). Knowing when you've brought them in: Scientific genre knowledge and communities of practice. *The Journal of the Learning Sciences*, *10*(3), 223-264.

Ortmeier-Hooper, C. (2008). English may be my second language, but I'm not'ESL'. *College composition and communication*, 389-419.

Paltridge, B. (2013). 18 Genre and English for Specific Purposes. *The handbook of English for specific purposes*, 347.

Paquot, M., & Granger, S. (2012). Formulaic language in learner corpora. *Annual Review of Applied Linguistics*, *32*, 130-149.

Peacock, M. (2002). Communicative moves in the discussion section of research articles. *System*, *30*(4), 479-497.

Pennycook, A. (2010). *Language as a local practice*. Routledge.

Pogner, K. H. (2003). Writing and interacting in the discourse community of engineering. *Journal of Pragmatics*, *35*(6), 855-867.

Purdue University. (2017). International students and scholars enrollment & statistical report fall 2017 [PDF file]. Retrieved from https://www.purdue.edu/IPPU/ISS/reports.html

Purdue University. (2019). Data digest. Retrieved from https://www.purdue.edu/datadigest/

Purdue University. (2019). First-year Engineering at Purdue. Retrieved from https://engineering.purdue.edu/ENE/Academics/FirstYear

Rahman, M. M. (2011). Genre-based writing instruction: Implications in ESP classroom. *English for Specific Purposes World*, *33*(11), 1-9.

Reave, L. (2004). Technical communication instruction in engineering schools: A survey of top-ranked US and Canadian programs. *Journal of Business and Technical Communication*, *18*(4), 452-490.

Reiff, M. J., & Bawarshi, A. (2011). Tracing discursive resources: How students use prior genre knowledge to negotiate new writing contexts in first-year composition. *Written Communication*, *28*(3), 312-337.

Richard, J. C., Mendoza Diaz, N. V., Wickliff, T. D., & Yoon, S. Y. (2016). Enculturation of diverse students to the engineering practices through first-year engineering college experiences. In *Proceedings of the 123rd American Society for Engineering Education (ASEE) Annual Conference and Exposition, New Orleans, LA, USA* (p. 26956).

Ruiying, Y., & Allison, D. (2004). Research articles in applied linguistics: structures from a functional perspective. *English for specific Purposes*, *23*(3), 264-279.

Rounsaville, A., Goldberg, R., & Bawarshi, A. (2008). From incomes to outcomes: FYW students' prior genre knowledge, meta-cognition, and the question of transfer. *WPA: Writing Program Administration*, *32*(1), 97-112.

Rundblad, G. (2007). Impersonal, general, and social: The use of metonymy versus passive voice in medical discourse. *Written Communication*, *24*(3), 250-277.

Sageev, P., & Romanowski, C. J. (2001). A message from recent engineering graduates in the workplace: Results of a survey on technical communication skills. *Journal of Engineering Education*, *90*(4), 685-693.

Savignon, S. J. (2018). Communicative competence. *The TESOL encyclopedia of English language teaching*, 1-7.

Scardamalia, M., & Bereiter, C. (1987). Knowledge telling and knowledge transforming in written composition. *Advances in applied psycholinguistics*, *2*, 142-175.

Schoonen, R., Gelderen, A. V., Glopper, K. D., Hulstijn, J., Simis, A., Snellings, P., & Stevenson, M. (2003). First language and second language writing: The role of linguistic knowledge, speed of processing, and metacognitive knowledge. *Language learning*, *53*(1), 165-202.

Schmidt, R. W. (1990). The role of consciousness in second language learning1. *Applied linguistics*, *11*(2), 129-158.

Shehadeh, A. (2003). Learner output, hypothesis testing, and internalizing linguistic knowledge. *System*, *31*(2), 155-171.

Slagley, J. M., & Smith, D. A. (2008, March). Designing a new program for ABET accreditation. In *American Society for Engineering Education North Central Section conference, Wright State University, Dayton, Ohio, United States of America* (pp. 28-29).

Smart, G., & Brown, N. (2006). Developing a “discursive gaze”: Participatory action research with student interns encountering new genres in the activity of the workplace. In N. Artemeva & A. Freedman (Eds.), Rhetorical genre studies and beyond (pp. 241-282). Winnipeg, MB: Inkshed.

Sommers, N., & Saltz, L. (2004). The novice as expert: Writing the freshman year. *College Composition and Communication*, *56*(1), 124-149.

Spinuzzi, C. (2003). *Tracing genres through organizations: A sociocultural approach to information design* (Vol. 1). Mit Press.

Staples, S. , Egbert, J. , Biber, D. and Conrad, S. (2015). Register Variation *A Corpus Approach*. In The Handbook of Discourse Analysis (eds D. Tannen, H. E. Hamilton and D. Schiffrin). doi:10.1002/9781118584194.ch24

Staples, S., Egbert, J., Biber, D., & Gray, B. (2016). Academic writing development at the university level: Phrasal and clausal complexity across level of study, discipline, and genre. *Written Communication*, *33*(2), 149-183.

Starfield, S. (2013). 24 Critical Perspectives on ESP. *The handbook of English for specific purposes*, 461.

Swales, J.M. (1981) *Aspects of Article Introductions* ESP Monograph No.1 Language Studies Unit: Aston University

Swales, J. (1987). Utilizing the literatures in teaching the research paper. *TESOL quarterly*, *21*(1), 41-68.

Swales, J. (1988). Discourse communities, genres and English as an international language. *World Englishes*, *7*(2), 211-220.

Swales, J. (1990). *Genre analysis: English in academic and research settings*. Cambridge University Press.

Soliday, M. (2011). *Everyday Genres : Writing Assignments Across the Disciplines*. Carbondale: Southern Illinois University Press.

Tardy, C. M. (2009). *Building genre knowledge*. West Lafayette, IN: Parlor Press.

Thomas, S. (2005, July). The engineering-technical writing connection: A rubric for effective communication. In *IPCC 2005. Proceedings. International Professional Communication Conference, 2005.* (pp. 517-523). IEEE.

Thomas, David R. (2006). A General Inductive Approach for Analyzing Qualitative Evaluation Data. *American Journal of Evaluation, 27*(2), 237-246.

Thonney, T. (2011). Teaching the conventions of academic discourse. *Teaching English in the Two Year College, 38*(4), 347.

Troy, C., Jesiek, B. K., Boyd, J., Buswell, N. T., & Essig, R. R. (2016, June). Writing to learn engineering: Identifying effective techniques for the integration of written communication into engineering classes and curricula (NSF RIGEE project). In *2016 ASEE Annual Conference & Exposition*.

Upton, T. A., & Connor, U. (2001). Using computerized corpus analysis to investigate the textlinguistic discourse moves of a genre. *English for Specific Purposes*, *20*(4), 313-329.

Varttala, T. (2001). *Hedging in scientifically oriented discourse. Exploring variation according to discipline and intended audience*. Tampere University Press.

Wardle, E. (2007). Understanding transfer from FYC: Preliminary results of a longitudinal study. *WPA: Writing Program Administration, 31*(1-2), 65-85.

Wardle, E. (2009). " Mutt Genres" and the Goal of FYC: Can We Help Students Write the Genres of the University?. *College Composition and Communication*, 765-789.

Wheeler, E., & McDonald, R. L. (2000). Writing in engineering courses. *Journal of Engineering Education*, *89*(4), 481-486.

Wilder, L. (2012). *Rhetorical Strategies and Genre Conventions in Literary Studies Teaching and Writing in the Disciplines.* Carbondale: Southern Illinois University Press.

Williams, J. M. (2001). Transformations in Technical Communication Pedagogy: Engineering, Writing, and the ABET Engineering Criteria 2000. *Technical Communication Quarterly*, *10*(2), 149-167.

Williams, J. M. (2002). The engineering portfolio: Communication, reflection, and student learning outcomes assessment. *International Journal of Engineering Education*, *18*(2), 199-207.

Winsor, D. (1998). Rhetorical Practices in Technical Work. *Journal of Business and Technical Communication*, *12*(3), 343-370.

Winsor, D. A. (1990). Engineering writing/writing engineering. *College composition and communication*, *41*(1), 58-70.

Winsor, D. A. (1999). Genre and activity systems: The role of documentation in maintaining and changing engineering activity systems. *Written communication*, *16*(2), 200-224.

Winsor, D. A. (2013). *Writing like an engineer: A rhetorical education*. Routledge.

Wray, A. (1999). Formulaic language in learners and native speakers. *Language teaching*, *32*(4), 213-231.

Yates, J., & Orlikowski, W. J. (1992). Genres of organizational communication: A structurational approach to studying communication and media. *Academy of management review*, *17*(2), 299-326.

Yore, L. D., Hand, B. M., & Prain, V. (2002). Scientists as writers. *Science Education*, *86*(5), 672-692.

Zappen, J. P. (1983). A rhetoric for research in sciences and technologies. *New essays in technical and scientific communication*, 123-138.