ENGINEERING DESIGN REPORTS
IN UPPER-DIVISION UNDERGRADUATE ENGINEERING COURSES
AND IN THE WORKPLACE

By Elena Poltavtchenko

A Dissertation

Submitted in Partial Fulfillment

of the Requirements for the Degree of

Doctor of Philosophy

in Applied Linguistics

Northern Arizona University

May 2013

Approved:

Douglas Biber, Ph.D., Co-Chair

Fredricka L. Stoller, Ed.D., Co-Chair

William Grabe, Ph.D.

Mary McGroarty, Ph.D.

Debra Larson, Ph.D.

ABSTRACT

ENGINEERING DESIGN REPORTS
IN UPPER-DIVISION UNDERGRADUATE ENGINEERING COURSES
AND IN THE WORKPLACE

ELENA POLTAVTCHENKO

The workplace success of new engineering graduates is ultimately affected by their oral and written communication skills. However, engineering students' academic preparation for industry's needs in terms of written communication has been widely acknowledged as inadequate. The present study is intended to improve our understanding of a prominent engineering genre, the engineering design report (EDR), and provide support for students learning to write this genre. The goals of this study are to (a) conduct a corpus-based register comparison between student and professional EDRs and (b) provide a more detailed description of professional EDRs, by determining their rhetorical organization and identifying linguistic features associated with this organization.

This research is based on two EDR corpora (N of texts=262, with approximately 1,119,186 words), one with upper-division engineering students' EDRs and the other with professional engineers' EDRs. The study examines both non-linguistic and linguistic features of student and professional EDRs. First, non-linguistic characteristics of EDRs are examined using the EDR situational framework developed for the study. Then, corpus-based methodologies are used to analyze core grammatical features and features associated with grammatical complexity in both corpora. Finally, to determine conventional discourse structures of professional EDRs, the study draws on the English for Specific Purposes tradition of genre analysis and then uses register analysis to investigate linguistic features associated with particular rhetorical structures.

The register analyses revealed complex patterns of linguistic variation, frequently influenced by the registers' situational characteristics. The results of these analyses indicate that two EDR registers fill different positions on the spoken-to-written continuum, with reports produced in the workplace being closer to professional written registers and student reports using more speech-like features. The genre analysis of professional EDRs uncovered the highly variable nature of this genre. Despite considerable variation in EDR rhetorical organization, 12 common moves were identified that cluster in specific ways to form EDR organizational units and rely on particular sets of linguistic features. A streamlined template of the EDR genre is introduced as are linguistic features associated with its organization. Study results may have pedagogical implications for teaching features of professional EDRs to students.

ACKNOWLEDGEMENTS

This dissertation would not have been possible without the encouragement and support of a great many people. First, I would like to thank Dr. Fredricka Stoller, my co-chair and mentor, who always offered words of wisdom and encouragement when I felt lost and doubted my ability to finish this project. The mentoring she provided has gone far beyond the scope of this dissertation. Thank you for providing so many opportunities for me to grow as a scholar and a member of our field, for sharing your knowledge, and for your great patience with the many obstacles I endured while writing this dissertation.

I also wholeheartedly thank Dr. Douglas Biber, my co-chair, whose enthusiasm and unwavering support for this project I cherish deeply. His research and courses at NAU introduced me to the world of corpus linguistics and were an inspiration for my study. His guidance, insight, and encouragement determined the success of this project.

I also owe tremendous gratitude to the members of my dissertation committee – Dr. Mary McGroarty, Dr. William Grabe, and Dr. Debra Larson. This study would not have been possible without their time, patience, interest, and a keen desire to help. Undoubtedly, their feedback throughout the various stages of the dissertation helped me develop as a student and a scholar. Thank you all for your constructive comments and thoughtful responses on drafts. In your own distinct way, each of you gave me much needed strength and support that I truly appreciate.

Many thanks also go to the participants of my study, engineering professionals, faculty, and students, who contributed information, time, and insight to this research. In particular, I would like to thank John Scaturro, Engineering Manager at GE Healthcare, for allowing me to interview company's engineers about the nature of the engineering design report (EDR) genre and writing processes associated with it in the workplace. I also thank all practicing engineers who agreed to participate in the study, Ali Ozmetin, Andrei Baikalov, Ben Gronemeyer, Charles Helms, Jim Moore, John Shurman, Kishore Mogatadakala, Sampath Kandala, Simon Lovell, Tesfaye Kidane, Tim Bergfeld, and Zhenyu Zhang, for their time, interest in my research, and eagerness to help.

I am also grateful to the engineering faculty at NAU, who participated and supported this project in so many different ways. I thank NAU professors John Tingerthal, Rand Decker, David Scott, and Bryan Cooperrider for their valuable time, thorough responses to the interview and survey questions, and willingness to take part in follow-ups. I would also like to acknowledge the contributions of these and other engineering faculty members at NAU, who helped me collect student EDRs for analyses, provided much needed insight into professional and writing practices in engineering, and showed great enthusiasm for this study.

In addition, I owe my deepest appreciation to my engineering expert informants, Dr. David Hartman and Dr. Walter Hopkins, who took their valuable time to help me ensure that the corpora compiled for the study contained only EDRs. I must also thank the two engineering student informants, Vanessa Smith and Lynette Lopez, who read professional EDRs with me and whose knowledge of engineering and EDRs played an integral part in the genre analysis. This dissertation study has benefited from the support and contribution of these engineering faculty and students immensely.

I am also grateful to the Applied Linguistics faculty and students at Northern Arizona University. I thank the faculty for their guidance and constant encouragement, which over the years helped me grow as a scholar and as a teacher. I am thankful to my fellow students, for their friendships, and intellectual and emotional support. You certainly made my graduate school experience and the writing of this dissertation much more enjoyable. I would also like to thank the English Department and the Program in Intensive English at Northern Arizona University as well as *Language Learning* Journal for financial support of this dissertation research.

I would also like to express gratitude to my friends in Arizona and South Carolina, who helped me not to get too overwhelmed by being a new mom and keep working on my dissertation. Thank you, Natalia, Lidia, Breanna, Eun Jung, Sarah, Jana, Ali, and Ligia, for making dinners, sharing stroller walks, and offering kind words of encouragement when I needed them most.

Without a doubt, my deepest gratitude goes to my family for their unending love and encouragement. My husband Andrei has been my most steadfast supporter. He gave me the strength to succeed, the confidence to believe in myself, and persistence to endure through stressful times. His belief in me encouraged me to move forward when I thought I could go no further. I am so grateful to have a caring, undemanding, and understanding husband by my side throughout this long endeavor. My son Max, who was born during the writing of this dissertation, has been a constant source of joy and a great motivation to finish the study. Finally, I want to thank my parents, Tamara and Alexander, who taught me to love reading and encouraged my writing since I scribbled my first word. Thank you for instilling in me intellectual curiosity and a desire to learn, for your unconditional love and support throughout my life.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1. INTRODUCTION

1.1. Importance of Communication Skills in the Workplace

In today's fast paced modern society, the importance of communication skills cannot be overstated. The world of work is changing every day, and more and more activities in this dynamic workplace revolve around communicating and processing information. In a broad sense, communication involves the transmission of information and meaning from one individual or group to another. Its central objective thus is the transmission of meaning, which can only be effective when the receiver understands an idea as it was intended by the sender.

According to Guffey (2004), several business trends illustrate the crucial role that communication skills play and will continue to play in the workplace. Specifically, the following trends make effective communication skills an essential attribute of a successful professional: Flattened management hierarchies, more participatory management, increased emphases on self-directed work and project teams, heightened global competition, new communication technologies and work environments, and the focus on information and knowledge as corporate assets. Therefore, developing effective communication skills is extremely important for one's future career. It is not surprising then that surveys of employers in various fields show that "communication skills are critical to effective job placement, performance, career advancement, and organizational success" (Guffey, 2004, p. 2). In fact, effective communication skills, both oral and written, are frequently ranked as one of the most requested competencies by employers (Wilhelm, 1999). Further, the results of another survey show that corporate executives rank writing skills as the skills most lacking in job candidates ("Wanted: Leaders", 1997).

1.2. Importance of Effective Writing Skills in Engineering

For a career in engineering, effective communication skills are crucial despite a common misconception that engineers deal mostly with quantitative information. In fact, a survey conducted in Finland in 1998 by the National Board of Education shows that while these assumptions may be true, "in addition to having to describe and solve technical problems, [engineers] are also expected to write both formal and informal documents" (Viel, 2002, para.7). Certainly, engineers use math and science in their designs, but they also need to clearly communicate those design solutions to others so that these designs can be constructed or manufactured. In fact, estimates indicate that as much as 80% of an engineer's work time may be spent on communicating (Ostheimer & White, 2005), with most engineers spending over 40% on writing alone (Beer & McMurrey, 1997). The higher engineers climb the professional job ladder of their companies toward management, the more writing is required of them (Beer & McMurrey, 1997; Schneiter, 2003, Sokoloff, 2003; Sorby & Bulleit, 2006). Quite regularly, engineers may only deal with documents written by other engineers (Winsor, 1996).

Further, previous research suggests that the workplace success of new engineering college graduates is ultimately affected by their oral and written communication skills (Ford, 2004). Thus, the importance of effective writing and communication skills for engineers is generally recognized and has consistently scored high on employers' lists of desirable attributes (Bandyopadhyay, 2006; Rorrer, 2003). More importantly, previous research has shown that while graduating engineering students are competent technically, they often lack communication skills, which prevents them from reaching their full potential in the workplace or academic careers (Kedrowicz & Kvidal, 2005; Robinson & Blair, 1995). In light of these facts, technical communication skills, and writing skills in particular, become especially important for engineers. Consequently, learning these skills is crucial for all engineering students.

1.3. Academic Preparation of Engineering Students for Professional Writing

The importance of effective oral, written, and graphical skills for the communication of ideas by future engineers was pointed out as early as 1955 in the Report of the Committee on Evaluation of Engineering Education (American Society for Engineering Education [ASEE]). However, while a range of approaches to teaching oral communication skills and writing to engineering undergraduates has been implemented, the inadequate preparation of new engineering hires to communicate effectively in the workplace has been widely acknowledged (Amare & Brammer, 2005; Gruber, Larson, Scott, & Neville, 1999; Kedrowicz & Kvidal, 2005; Schneiter, 2003; Sokoloff, 2003; Wojahn, Dyke, Riley, Hensel, & Brown, 2001).

In fact, the discrepancy between the industry's needs and the academic preparation of engineering students in written and oral communication is recognized not only in the US, but in other countries as well. For instance, Canadian engineering faculty constantly receive complaints from industry about the poor writing skills of newly hired engineers (Sokoloff, 2003). Such complaints echo the dissatisfaction with engineering graduates' professional preparation voiced by US companies and ABET (known as Accreditation Board for Engineering and Technology before 2005), an organization responsible for accrediting American engineering and technology programs. Both US employers of new engineering graduates and ABET argue that in this modern, constantly changing society, it is not enough for engineers to hold only superior technical skills. Graduates should also be able to communicate effectively, perform well in the global workplace, function in multidisciplinary teams, and use problem-solving and critical-thinking skills (ABET, 2013; Williams, 2001; Wojahn et al., 2001). Among other requirements, ABET 2000 requires engineering programs to demonstrate how well graduating students can complete tasks required by their future employers (Driskill, 2000). Recent changes in ABET engineering accreditation criteria have stimulated the interest of scholars from various fields, including those in rhetoric and technical communication, to study student performance from multiple perspectives. Because one of the criteria that institutions undergoing ABET's accreditation must meet is students' "ability to communicate effectively" both verbally and in writing (ABET, 2013, p. 3), it is not surprising that one of these areas of interest is the writing of engineering students.

Importantly, students' perceived notion that engineers generally do not need to write and the diametrically opposed perceptions of engineering faculty and industry that students lack the writing skills necessary for successful professional careers further exacerbate the difficulties in successful implementation of writing in engineering (Gruber et al., 1999). Further, the lack of preparation of future engineers for the demands of the industry may be also attributed to the insufficient instruction provided to high school students who then enroll in engineering programs. For instance, 10% to 20% of incoming students at the University of Waterloo, the elite southern Ontario engineering school, fail basic writing exams and are required to take remedial English classes despite their high school averages of more than 90% (Sokoloff, 2003). Finally, the vastly diverse student populations on some campuses (with possibly up to 85% of students being non-native speaking [NNS] engineering students) may present additional problems for improving the technical communication skills and writing of engineering undergraduates (Nelson, 2004).

Notably, these NNS engineering undergraduates consist of various groups of linguistically and culturally diverse students. In addition to the growing numbers of international students at universities in English-speaking countries (Melles, 2003), and American universities in particular (Braine, 1995), there is an even larger number of immigrant students who have been immersed in the American school system possibly since middle school and who have chosen to major in engineering. These immigrant students, often referred to as the Generation 1.5 group, may have native-like language control in listening and speaking, but their reading and writing skills may suffer from the same issues that English as a Second or Foreign Language (ESL/EFL) students usually have (Chiang & Schmida, 1999; Reid, 1998, 2006; Rodby, 1999). Moreover, Generation 1.5 students, unlike the majority of international students, may also be inexperienced writers not only in English, but also in their first languages (Jacoby, Leech, & Holten, 1995), making it even harder for such students to acquire the writing skills necessary in their majors.

Regardless of their linguistic backgrounds and the unique challenges associated with writing in engineering, these NNS engineering students need to become effective at communicating their ideas to peers and engineering faculty to succeed in college and beyond. To be able to communicate effectively in English-speaking countries or internationally, an engineer for whom English is not a native language needs to know English grammar and writing conventions as well as discourse-specific features of written communication expected by the engineering community. Therefore, NNS engineers may need to work hard learning both engineering subject matter and English, investing time and effort in this process beyond that required of native speaking (NS) engineering students. Importantly, despite these additional challenges and steps that NNS students need to take, after they reach proficiency in general academic English, they need to become socialized into engineering written discourse just like NS engineering students do. It is clear then that effective discipline-specific written communication skills are equally important for successful careers in engineering for NS and NNS engineers.

Moreover, the need for effective instruction on discipline-specific writing is further highlighted by the continued increase in volume of scientific information and cross-cultural communication in written (as well as spoken) forms. In many disciplines, English has become "a common language, a lingua franca, which allows for ease of information storage and retrieval that may be more efficient than translation and provides a means for knowledge advancement" (Tardy, 2004, p. 248). This tendency is true for the field of engineering as well, where with the increase of international contacts, the globalization of engineering education and research is a reality today (King, 2006; Owens & Fortenberry, 2007). To further technological innovations and international engineering interactions, future engineers in various countries need to be able to communicate effectively in a non-native environment by means of English, in particular. There is a demand, therefore, for efficient English education and language support for future engineers, and it is not surprising that English for Specific Purposes (ESP) programs are in great demand (Mudraya, 2004b, 2006; Narita, Kurokawa, & Utsuro, 2003; Sysoyev, 2000). However, as pointed out by Orr (2003),

> The number of programs that target the specific English needs of students and professionals in S&E [Science and Engineering] is amazingly small, as is the

number of professionals who specialize in developing language programs, products, and services for the S&E market. (p. 154)

As the previous discussion shows, there is a pressing need for effective instruction about discipline-specific discourse for future NS and NNS engineers alike. To provide effective instruction on features of professional engineering written discourse to engineering students, materials need to be developed based on the results of empirical studies investigating common engineering genres that students will most likely be asked to produce in their careers. The present study focuses on one of these genres, the engineering design report (EDR). The following section introduces this important engineering written genre and situates it within other engineering reporting genres.

1.4. What are EDRs?

The engineering design report (EDR) is one of the prominent written engineering genres, frequently required of both upper-division university engineering students and practicing engineers in the workplace. In both academic and professional settings, EDRs are formal written documents that describe all relevant technical work and outcomes of an engineering design project, a project in which engineers apply previously learned knowledge and skills to design an artifact[1] that meets a stated objective. EDRs often have dual audiences that include (a) engineers and scientists interested in the functionality and feasibility of the engineering design and (b) management interested in the design's application(s) and effectiveness.

[1] Artifacts are products conceived, produced, transacted, and used by people because of their properties and the functions they may perform. According to Dym (1994), "engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints" (p. 17).

Notably, the EDR is only one of the many types of reports that engineers produce throughout their careers. The EDR genre does not exist in a vacuum and is interconnected with many other engineering genres, both related and unrelated to the design project. For example, EDRs are typically written after a design project has been completed and, therefore, are produced after other project-related documents, such as proposals and progress reports, have been written and distributed to target audiences. Further, EDRs belong to a broader genre of engineering technical reports, which, in turn belong to an overarching genre of reports.

In the course of their careers, many different types of reports are written by engineers including design, progress, research, recommendation, and feasibility reports to name a few. These documents often have different communicative purposes and are written for diverse audiences, which have consequences in terms of (a) how engineers organize these various documents rhetorically and (b) what linguistic features engineers use when writing them. It is, therefore, necessary to further examine similarities and differences between these reporting genres so that EDRs can be clearly differentiated and subsequently analyzed rhetorically and linguistically. Such descriptions are provided in various sections of Chapter 2. Specifically, Sections 2.1.2 and 2.1.3 examine common engineering written genres in professional and academic settings, respectively. Section 2.2 then discusses the broad genre of engineering technical reports whereas Section 2.3 focuses on specific functions, characteristics, and distinguishing features of EDRs.

1.5. Overview of the Study

The overall goals of this study are (a) to conduct a corpus-based register comparison between student and professional EDRs and (b) provide a more detailed description of professional EDRs by determining their general rhetorical organization and identifying linguistic features associated with this organization. Because engineering design reports are commonly required of all engineering students enrolled in design classes and because these reports are frequently written by professional engineers, the results of the study may have pedagogical implications for teaching features of professional engineering written discourse to engineering students. Five important features of the study are described below.

First, unlike most previous studies, the present study uses two complementary methods of discourse analysis to enable a more comprehensive examination of professional EDRs. Specifically, the study examines professional EDRs from two major perspectives: (a) by means of register-based analysis, the study employs corpus-based methodologies and thus focuses on the surface linguistic features of the texts, and (b) by using a genre-based analysis, the study focuses on the internal discourse organization of texts.

Second, to contextualize both genre- and register-based analyses and enable subsequent functional interpretations of their results, the study includes a thorough situational analysis of EDRs written in professional and academic settings. Specifically, the study develops and applies an analytical framework for analyzing the situational characteristics of EDRs. To enable comprehensive functional interpretations, the framework of situational characteristics created for the present research includes eight situational parameters and covers twenty two characteristics, most of which contain several levels. The framework includes characteristics that have been shown to correspond to language use in many registers and those that have been particularly important in discussions of disciplinary writing.

Third, to distinguish between EDRs written by professional engineers in the workplace and engineering students in upper-division university courses, the study seeks to go beyond the previous analyses, which have usually consisted of one or only a few linguistic features. Specifically, the present research examines a range of lexical and grammatical characteristics of professional and student EDRs.

Fourth, for the genre analysis of professional EDRs, the study develops an analytical framework drawing on the textual perspective of genre analysis in the ESP tradition (Swales, 1990, 2004) and extending it to include text-external factors. For genre analysis, the study utilizes previous research in cognitive text analysis (Bartholomew, 1993) and specialized literature on design reports, including textbooks on the engineering design process (Dominick et al., 2001; Eide et al., 2002; Jenkinson & Marchman, 2003) and engineering writing textbooks (Finkelstein, 2005; Silyn-Roberts, 2000; Sorby & Bulleit, 2006).

Finally, the last stage of the study involves a synthesis of all three analyses: Genre, situational, and register. During this stage, the results of the three analyses are brought together based on the functional relationships between the linguistic patterns, discourse structures, and situational characteristics of texts. With well-thought out analyses procedures, the study provides a principled and comprehensive means of examining associations between linguistic features, rhetorical structure, and situational characteristics of EDRs written in professional and academic settings.

1.6. Outline of the Dissertation

The present dissertation study investigates issues related to the development of effective written communication skills required of practicing engineers. The dissertation introduction has painted a broad picture of the communication skills considered important in the field of engineering, with an emphasis on the role that effective writing skills play in the lives of professional engineers. The introduction then pointed out the discrepancy between the requirements of the workplace and the academic preparation of engineering students in terms of their writing.

Chapter 2 of the dissertation, the literature review, explores the most common written genres in the field of engineering, specifically focusing on the engineering design report (EDR) genre. After an overview of existing literature on engineering genres, in general, and EDRs, in particular, the chapter discusses studies that approach discourse analysis from either a genre or register perspective and then highlights the need for combining these two approaches to study EDRs. The chapter concludes with a list of research questions for the present study of EDRs.

Chapter 3 presents the non-linguistic analysis, which examines the situational characteristics of student and professional EDRs. In Chapter 3, a detailed framework for describing situational characteristics of EDRs is proposed and validated through semi-structured interviews with and surveys of professional engineers writing EDRs and engineering faculty assigning EDRs to students. The situational characteristics of EDRs are then analyzed by using the results of the interviews and surveys. Chapter 4 describes the two EDR corpora built for the purposes of this study and explains the standard methodological procedures used in the dissertation.

Chapter 5 introduces the methodological steps used for the register- and genre-based analyses of the study. Chapters 6 and 7 then turn to the linguistic analyses carried out in the dissertation. Chapter 6 focuses on the grammar and lexis of student and professional EDR registers, reporting on the results of a study into the distribution of core grammatical features, semantic sets of lexical items, and features associated with grammatical complexity. Chapter 7 further analyzes the language of professional EDRs by first using genre analysis to examine their rhetorical structures and then employing register analysis to investigate core lexico-grammatical features of major organizational units within professional EDRs.

Finally, Chapter 8 discusses and synthesizes the results of the three analyses used in this dissertation – situational, register, and genre – showing that each approach leads to complementary information about the EDR genre. This chapter also discusses implications of the findings presented in Chapters 3, 6, and 7. Study limitations and future directions of this research conclude Chapter 8 and the dissertation.

CHAPTER 2. LITERATURE REVIEW

This chapter examines common approaches to studying written genres found in the engineering workplace and in academia. The chapter first defines the concept of genre and describes the most common approaches to genre analysis, followed by a discussion of the approach to genre analysis used in the present study. Then common written engineering genres in professional and academic settings are discussed. Next, the chapter discusses the concept of a genre colony and focuses on a particularly important "super-genre" found in both professional and academic engineering contexts, the engineering technical report. The chapter then specifically concentrates on the engineering design report (EDR), an important sub-genre of engineering technical reports. A survey of studies investigating design reports is then presented to show the paucity of such research.

The chapter then reports on research that employs both genre- and register-based approaches to studying academic and professional discourses, concluding that this research remains limited and is virtually absent in investigations of engineering discourse. Because research examining EDRs is virtually non-existent, to better understand this critical engineering genre, the present study uses two complementary approaches to discourse analysis: (a) analysis of the discourse structure of professional EDRs by means of genre-based methodology and (b) register analysis of EDRs through the use of corpus-based methods. The chapter concludes with a list of research questions for the investigation of EDRs written in the workplace and in upper-division engineering classes.

2.1. Genre Analysis Studies in Engineering

With the importance of writing in engineering being recognized by both employers and faculty, it is interesting to see just what kinds of writing are produced in the engineering workplace and in upper-division engineering classes. Textbooks on engineering writing frequently emphasize that "research, development, finance, manufacturing, and a host of technical commercial services rely on precisely written documents to communicate complex information to a wide range of audiences for many purposes" (Finkelstein, 2005, p. 1). Most of these written documents thus revolve around engineering design processes and represent a variety of genres. Before these genres can be discussed though, the concept of genre needs to be defined and situated within the field of engineering.

2.1.1 Common Approaches to Genre

At least three different approaches to genre analysis can be identified following Hyon (1996): The English for Specific Purposes (ESP) approach, the systemic-functional or Sydney School approach, and the New Rhetoric approach. In the ESP tradition put forth by Swales (1990) and further developed by such ESP practitioners as Bhatia (1993), genres are viewed as communicative events whose members share communicative purposes. Genres are staged events that develop through a sequence of moves and component steps (Bhatia, 1993; Swales, 1990, 2004) and therefore can be examined by means of move analysis. In move analysis, the text is described as a sequence of *moves*, each corresponding to a particular communicative purpose and each consisting of a set of component *steps*.

Thus, move analysis begins with the development of a framework of all possible moves of a particular genre. A small sample of texts belonging to the genre is then coded in terms of move types, and the overall genre structure is then described as a sequence of particular move types. For example, the Create a Research Space (CARS) model (Swales, 1990) has been very influential and fueled a number of genre-based studies in various disciplines (Anthony, 1999; Kwan, 2006; Promsin, 2006; Salager-Meyer, 1992; Samraj, 2005). The CARS model was created to depict research article introductions, which includes three moves: Establishing a Territory, Establishing a Niche, and Occupying a Niche. However, this sequence may vary between different instances of a genre, that is, some moves may be optional whereas some may occur in a different order, embedded in others, or repeated. While Swales focused on academic genres, particularly on research articles, Bhatia furthered this work and included such professional written genres as application letters and sales letters. Bhatia's (1993) basic four-part move structure for abstracts (i.e., introducing purpose, describing methodology, summarizing results, presenting conclusions) has also been applied in a number of studies (Promsin, 2006; Samraj, 2005), especially because abstracts are becoming such a prominent genre with the increase in technical and scientific information in recent decades. The primary motivation for advocates of the ESP approach has been the development of pedagogical materials for NNSs of English.

Another approach to genre referred to as the systemic-functional approach, or the Sydney School, has its roots in Hallidayan functional linguistics (Halliday, 1994). Because the Sydney School emphasizes the schematic structure of genres and the links between language and context, within this approach, genres are viewed as broad rhetorical patterns, such as narratives or arguments (Martin, 1992). Similar to the ESP approach, the Sydney School has a well-developed genre-based pedagogy, most notably a teaching-learning cycle consisting of modeling and deconstruction of text, joint construction of text, and independent construction of text (Cope & Kalantzis, 1993; Feez, 1998, as cited in Hyland, 2007b). However, unlike the ESP approach to genre analysis, which has mainly focused on NNS writing produced by adult second language learners in academic settings, the goals of the systemic-functional approach have revolved around helping secondary school children. Specifically, proponents of the systemic-functional approach believe that even young learners can understand why (i.e., the purposes for which) genres are used, how they are structured, and what important linguistic features they employ. Therefore, language educators can help students by describing the typical stages and language of particular genres. Despite a number of differences between the ESP and systemic-functional approaches, they have a lot in common. Because of their primary focus on textual analysis of genres, some researchers combine them into a unified text-based approach to genre analysis (Flowerdew & Peacock, 2001).

The third approach, the New Rhetoric, takes a rather different view of genre. This approach is mainly concerned with composition studies and professional writing in one's first language. Drawing on Miller's (1984) view of genre as a social action, scholars subscribing to this view of genre argue that to analyze genres, research needs to examine not their forms, but the actions these genres are used to accomplish (Freedman & Medway, 1994). As a result, in this tradition, genres are viewed as relatively unstable, dynamic structures that can be manipulated by their participants or change due to their context. The New Rhetoric group also stresses the importance of intertextuality of genres, which has led to the development of several frameworks to describe the groups of genres working together in a community (Artemeva, 2004; Spinuzzi, 2004). The more open-ended view of genre within the New Rhetoric School has two important outcomes. First, because the focus of genre analysis is on actions, beliefs, and behaviors of a discourse community rather than on the forms characteristic of a particular genre, the methodology used for studies in this line of inquiry is ethnographic as opposed to linguistic (Dias & Paré, 2000; Freedman & Adam, 2000). Second, the dynamic view of genres naturally leads proponents of this approach to be skeptical of the pedagogical value of genre analysis. Thus, unlike the ESP approach and the Sydney School, the New Rhetoric School does not have an easily identified pedagogy associated with it.

2.1.2 Common Engineering Genres in Professional Settings

Despite the importance of teaching disciplinary genres and their features to students in various disciplines, including engineering, little research has been conducted to date to explore professional written genres, their purposes, and contexts by using text-based approaches (i.e., ESP and systemic-functional approaches) to genre analysis (Flowerdew & Wan, 2006, 2010; Luzón, 2002). Studies following this line of genre analysis examine the structure, lexico-grammatical features, and conventions of professional genres with the purpose of helping students becoming more proficient in reading and writing such genres. Several of these genre analyses examine technical reports (Bartholomew, 1993; Flowerdew, 2000, 2004, 2008; Kotecha, 1991; Marshall, 1991; McKenna, 1997; Weinstein, 1987) and will be discussed in Section 2.2.1. Other professional engineering genres examined using text-based approaches to genre include technical proposals (Butler, 1987; McIssac & Aschauer, 1990; Whalen, 1986), memos

(Amare & Brammer, 2005), patents and specifications (Whalen, 1985), and oral presentations (Seliman, 1995).

Research on professional engineering genres from the social perspective of the New Rhetoric tradition has been fruitful and is grounded in disciplinary knowledge that is negotiated within a community of practice rather than passed from one person to another (Winsor, 1996). One of the frameworks used in this line of research was that of Activity Theory in which genres are viewed as tools used to carry out socially organized activities within a community (Artemeva, 2004; Luzón, 2005). Educators working in this line of scientific inquiry believe that Activity Theory helps broaden students' repertoire of analytical skills from "a focus on text and audience to a focus on context and the role of texts in mediating activities" (Kain & Wardle, 2005). Thus, regular activities within a community, the organization of such a community, and shared knowledge among its members become important when studying genres from this perspective. Following the New Rhetoric approach to genre analysis, this line of research also examines the interconnectedness of genres used by a community of practice because "the success of any given genre depends on its interconnections with other genres and how these genres jointly mediate a given activity" (Spinuzzi, 2004, pp. 5–6).

Following this approach, Orr's (2003) study explored the generic landscape in the field of computer science and computer engineering. By surveying nearly 200 computing professionals, Orr identified approximately 90 written genres and then organized them according to the five most important communicative purposes shared by discourse community members. Certainly, knowing the entire generic repertoire of a particular discourse community helps educators "better understand genres as they exist in natural disciplinary contexts" (Orr, 1999, p. 36). Yet, as Orr acknowledges, identifying the core genres in a particular discipline is just the beginning of research that aims to fully understand a discipline's genres and how to use them effectively. In particular, Orr identifies several directions for future research, including studies to detail generic description, studies of genre in professional contexts, studies of efficient and inefficient writing practices in the production of particular genres, studies of genre education for better acculturation to a discipline, and comparative studies of genres in different contexts.

Although the New Rhetoric tradition is not associated with easily identifiable pedagogy, researchers working in this tradition use Activity Theory to teach professional genres to students. As opposed to text-based genre pedagogies in which genre structures and their linguistic features are taught explicitly, social perspectives on genre entail teaching genres by placing students within the social context of a community of practice. Researchers working in this tradition believe that by entering a community of practice, students will face rhetorical situations and challenges (that often cannot be presented and/or addressed in academic settings) and therefore become enculturated into a particular community (Kryder, 1999; Winsor, 2006). In the enculturation model, genres are learned by active participation in activities and negotiations of meaning in the community. Following this view of teaching genres, studies have (a) addressed the engineering genres of the analytical report (Sheehan & Flood, 1999), engineer's logbook (McAlpine, Hicks, Huet, & Culley, 2006), and energy concept (Pogner, 2003); (b) explored engineering documentation prompting others to perform future actions (Winsor, 1999) and communication among engineering design team members (Baird, Moore, &

Jagodzinski, 2000); (c) discussed cultural challenges involved in writing periodic engineering reports (Artemeva, 1998); and (d) considered opportunities for classroom-workplace collaboration (Winsor, 1996; Wojahn et al., 2001).

2.1.3 Common Engineering Genres in Academic Settings

Most descriptions of engineering genres supposedly written in the workplace and consequently intended for instruction in academic settings can be found in textbooks on technical and engineering writing. Chapters found in these textbooks generally cover such genres as resumes, cover letters, business letters, memoranda, emails, laboratory reports, specifications, instructions, manuals, proposals, progress reports, and technical reports (e.g., Beer & McMurrey, 1997; Finkelstein, 2005; Kliment, 1998; Paradis & Zimmerman, 1997; Roden & Murphy, 2009; Sorby & Bulleit, 2006). While these writing textbooks provide useful overviews of possible genres encountered in the engineering workplace, they are frequently based on the individual experiences and perceptions of textbook writers, who do not necessarily paint an accurate picture of the dynamic generic landscape found in engineering professional settings (Orr, 1999). Moreover, these textbooks typically only briefly describe the content and overall general structure of each document, without much regard to language conventions preferred by members of the engineering discourse community.

A different approach to descriptions of engineering genres can be found in Braine's (1989) dissertation study of the writing tasks assigned in undergraduate natural science and engineering courses. By using a content analysis of syllabi and assignments obtained from instructors of courses offered by a College of Natural Sciences and a College of Engineering, Braine was able to (a) identify the range of writing tasks assigned in natural science and engineering courses at the undergraduate level, (b) classify them according to a pedagogically feasible taxonomy, and (c) draw pedagogical implications based on his findings. This study shed light onto writing practices in undergraduate courses in the natural sciences and engineering. However, following the overall tradition of the 1980s, Braine did not differentiate among the multiple discourse communities comprising these two colleges, claiming they belong to one discourse community. This oversight may make his findings less accurate for the field of engineering and therefore less valuable in terms of his pedagogical implications for engineering faculty and students.

One academic genre in particular, research article, traditionally has received a lot of attention among researchers. Since Swales' seminal work (1990), his move analysis methodology has been applied to the examination of the structure of introductions of research articles in engineering (Anthony, 1999; Kanoksilapatham, 2012) and to full engineering research articles and research theses (Koutsantoni, 2006). Also examined were other engineering genres, such as abstracts of engineering Master's theses (Promsin, 2006). Using a small corpus of 40 engineering abstracts from research theses written in English by Thai students, Promsin (2006) investigated whether the macro-organization of these abstracts (i.e., their rhetorical moves) follow Swales's CARS model and Bhatia's abstract move structure. The author reported that although student abstracts seem to follow the overall move structure outlined in the two models, the optional use of some components (e.g., *Move 2 – Establishing a niche* in CARS model and *Move 4 – Presenting a conclusion* in Bhatia's model) made them different.

Flowerdew (2004, 2008) applied the systemic-functional APPRAISAL framework (discussed in Section 2.2.1) to the analysis of the problem-solution pattern in engineering environmental reports. Walker (1999) emphasized the importance of teaching form and content of engineering laboratory reports. Shalamova (2008) examined rhetorical dimensions of six self-study reports composed by engineering faculty in a U.S.-based university for ABET. Her results demonstrated that self-study reports were not indifferent to rhetoric. Specifically, the study indicates that the two distinct rhetorical strategies of objectivity and accountability invoked by the self-study writers correspond to the norms and conventions of the engineering discourse community and are reflected both in rhetorical forms and language.

Further, recently, there has been interest on the part of many English for Academic Purposes (EAP) researchers and practitioners in cross-disciplinary comparisons of various genres, especially between hard and soft sciences (Hyland & Bondi, 2006). Studies involving engineering academic genres include the analysis of the rhetorical structures of and textual interaction in academic genres across several disciplines (Hyland, 2006) and a study of mathematical expressions and the roles that they play in academic texts from engineering, physics, and mathematics (Shaw, 2006).

The social view of genre has also been applied to investigations of engineering academic genres; however, considering the emphasis that this view places on the context of genres within communities of practice, it is not surprising that only a few investigations in this vein focus on academic engineering genres. In a longitudinal case study, Winsor (1996) examined writing habits and attitudes toward writing of four engineering students. In a similar vein, Tardy (2009) investigated the writing experiences of four multilingual graduate students in engineering and computer sciences over different periods of time. In a qualitative case study, Räisänen (1998) took a socio-cultural perspective to study conference genres, such as conference speeches and discussion papers, in the multidisciplinary field of crash-safety engineering. Finally, some scholars have argued the usefulness of Activity Theory for the design of engineering communication classes (Artemeva, Logie, & St-Martin, 1999) and multi-major professional communication courses (Kain & Wardle, 2005).

Additionally, research on engineering writing in academic settings is frequently reported in American Society of Engineering Education (ASEE) conference proceedings and deals with technical communications components in engineering curricula (Beams & Niiler, 2004; Blair & Robinson, 1995; Daniell, Figliola, Moline, & Young, 2003; Garland, Duerden, Helfers, & Evans,1999; Hanson & Williams, 2004; Hirsch et al., 2005; Linsky & Georgi, 2005; Manion & Adams, 2005; McNair, Norback, & Miller, 2005; Moore & Strueber, 2004; Nelson, 2004; Norback, Forehand, & Sutley-Fish, 2004; Rhoulac & Crenshaw, 2006; Terry, Ruchhoeft, Bannerot, & Kastor, 2004; Young & Alford, 1999) or assessment of various writing assignments in the field of engineering (Brocato, Harden, & Chapman, 2005; Swarts & Odell, 2001; Wikoff, Friauf, Tran, Reyer, & Petersen, 2004). These investigations often focus on the teaching experiences of engineering or technical communications faculty in a particular class and may not involve a data-driven approach to student texts. While this line of research makes valuable additions to the growing body of research on teaching engineering discourse to students, these studies are not concerned with the rhetorical organization or linguistic features used by students in engineering written genres.

2.1.4 Approach to Genre Used in the Present Study

This study draws on several approaches to genre analysis. In particular, following Bhatia (1996, 2001, 2002, 2004, 2006), the study views genre analysis as the study of situated linguistic behavior, as a means of

> investigating instances of conventionalised or institutionalised textual artefacts in the context of specific institutional and disciplinary practices, procedures and cultures in order to understand how members of specific discourse communities construct, interpret, and use the genres to achieve their community goals and why they write them the way they do. (Bhatia, 2002, p. 6)

Such an approach to genre analysis allows one to see that despite the different motivations of various approaches to genre analysis, genre analysis involves the investigation of discursive practices to gain a better understanding of "the disciplinary, institutional, organizational or professional practices of specialist communities" (Bhatia, 2006, p. 14). Although the scope of this study does not allow for the use of Bhatia's (2004) three-space model of discourse analysis, which attempts to integrate various approaches to genre analysis, the present research seeks to describe engineering design reports not only in terms of their textual features, but to extend this analysis beyond the text to incorporate text-external factors that may help account for the way EDRs are interpreted and used in specific institutional and professional contexts. The study thus examines EDRs within two spaces of Bhatia's (2004) three-space model: Textual space and socio-pragmatic space.

In terms of analyzing EDRs from the textual perspective, the study draws on the ESP approach because the ultimate goal of the present research is to use genre analysis as a tool for teaching discipline-specific writing to NNS and NS engineering students in upper-division engineering courses. Most language scholars who follow the ESP tradition define a *genre* as a category of discourse, either written or spoken, that (a) is distinguished by similar features and goals and (b) serves as a response to the demands of social context (Cheng, 2008; Flowerdew, 2000, 2001; Hyland, 2007b; Swales, 1990, 2004). Therefore, ESP scholars often link genres to particular discourse communities (Hyland & Bondi, 2006). The members of such discourse communities are united by common goals and share certain values and preferences for language use. Discourse communities often rely on a unique corpus of genres that differ in various aspects from genres preferred in other discourse communities (Orr, 1999). Thus, to a certain extent, genres can be thought of as agreements among discourse community members about document features and language uses deemed acceptable.

As a result, members of a particular discourse community typically can, without much difficulty, recognize similarities in texts that they frequently read or write. Because writing is based on reader expectations, conforming to genre conventions makes communication in a discourse community more efficient. In other words, matching the expectations of the members of one's discourse community narrows down the range of possible intentions for recurring kinds of communication and thus enables readers to give more attention to the content of the document rather than to its structure and purpose (Hyland, 2000; Orr, 1999). Thus, a lack of awareness of disciplinary genres and their features hinders one's successful communication within a disciplinary community and can become a considerable problem for one's written work to be perceived as professional. Naturally then, genre-based pedagogies can help writing instructors assist students in various disciplines become more advanced readers and writers by making students aware of, among other things, the rhetorical organization of genres conventionally used in their disciplines. For instance, to facilitate the reading and writing of discipline-specific written genres, students can be asked to read and analyze relevant texts that they will have to write in professional contexts after graduation (Cheng, 2008; Hyland, 2007b; Robinson, Stoller, Costanza-Robinson, & Jones, 2008).

In terms of analyzing EDRs from the socio-cognitive perspective, the study seeks to incorporate the broader context in which EDRs exist in order to shed light on reasons for which engineers construct their discourse the way they do. Regrettably, ethnographic investigations of institutional and professional contexts are beyond the scope of the present research. However, the study seeks to examine how EDRs are used in different contexts within the engineering community. Therefore, the present research attempts to view professional practices more critically, integrating text-internal and text-external perspectives and accounting for the dynamic and flexible nature of genres that are influenced by a number of contributing factors.

Before the importance of EDRs can be discussed and some of its prominent features can be identified in the following sections, it should be noted that EDRs belong to a broader genre of engineering technical reports (ETRs), which, following the genre colony theory (Bhatia, 2004), in turn belong to the super-genre of reports, or reporting genres (see Table 2.1). The notion of genre colonies allows one to apply genre analysis (a) within and across disciplines and domains and (b) with varying degree of specificity (Bhatia, 2001, 2004). It also helps to show distinctiveness as well as overlap in various features among the genres within a particular colony. For example, although reports from various disciplines all share a general overlapping communicative purpose of reporting on particular events, they also demonstrate variation in the use of rhetorical structures and lexico-grammatical choices. This variation can depend on one or several additional factors, such as a discipline, a specific communicative purpose, or a medium, to name a few.

Table 2.1 Versatility in generic description (adapted from Bhatia, 2004)

Identification Criteria	Genre Specification			Genre Level
General communicative purpose		Reporting Genres		Genre colony (Super-genre)
Discipline: Engineering	Progress Reports	Technical Reports	Trip Reports	Genre
Specific communicative purpose/ Product	Engineering Design Reports		Engineering Research Reports	Sub-genre

The following sections, thus, will (a) situate the sub-genre of EDR within the more encompassing genre of engineering technical report (ETR), (b) discuss specific factors that lead to overlapping or distinguishing characteristics of EDRs and ETRs, and (c) specifically focus on differentiating EDRs and engineering research reports (ERRs), which also belong to the overarching ETR genre and could be mistaken for EDRs at first glance. After EDRs are situated within the genre of ETR and their distinguishing characteristics are discussed, the subsequent sections present research examining both ETRs and EDRs. It seems reasonable to include here studies on ETRs because there is very little research on EDRs and there is overlap in some features between EDRs and ETRs, so examining studies on ETRs may help shed light on features of both ETRs and EDRs.

2.2. Engineering Technical Reports

According to multiple textbooks and guides on technical and engineering writing (Beer & McMurrey, 1997; Finkelstein, 2005; Roden & Murphy, 2009; Sorby & Bulleit, 2006), engineering technical reports (ETRs) are formal documents that are usually (a) produced in response to a specific request or research need and (b) written after a project has been completed. Unlike proposals that are also written in response to a particular need typically identified in a formal request for proposal (RFP), technical reports are only produced after the project has been awarded to an organization with an optimal proposal and after the work on that project has been fully or partially completed. These reports typically include research about technical concepts as well as graphical depictions of designs and data. They may serve as reports of accountability to funding organizations and are typically written for the following purposes: (a) to give an overview of how a design, an analysis, or an engineering study was accomplished, (b) to provide a thorough description of all useful technical work completed for the project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a project. ETRs can be written individually or entail a collective effort (Poltavtchenko, 2010a).

Today ETRs are a major source of technical information that can be prepared for internal or wider distribution by many organizations. Internal ETRs may lack the extensive editing and professional presentation one sees in published documents. On the other hand, ETRs are also frequently prepared for sponsors of various engineering projects. Thus, according to the U.S. Army Engineer Research and Development Center (ERDC) (2006), the ETR is the “principal vehicle for documenting the results of a sponsored research and development project that has been completed or terminated” (p.

2). An ETR prepared for ERDC may also report on "significant milestones achieved during a phased or multi-year project" (p. 2). ETRs written for sponsoring organizations, such as the ERDC, typically conform to writing guidelines provided by the sponsoring agency. It is expected that they will contain all essential information needed for the reader and that this information will be clearly and succinctly presented so that it is "easy to use by readers at the executive, planning, using, and reference worker levels in the target audience" (ERDC, 2006, p. 1).

Textbooks on technical and engineering writing typically claim that ETRs are frequently written in both professional and academic settings (Beer & McMurrey, 1997; Finkelstein, 2005; Roden & Murphy, 2009; Sorby & Bulleit, 2006). Their crucial role as permanent records of an engineering project is also recognized by such organizations as the National Information Standards Organization (NISO), a non-profit association accredited by the American National Standards Institute (ANSI) that identifies, develops, and publishes technical standards to manage information in a contemporary digital environment. Thus, in 2005, acknowledging the need to foster uniformity in technical reports "for ease of information retrieval while permitting diversity in presentation based on the rapidly changing environment driven by the growing digital environment" (ANSI/NISO, 2005, p. vii), NISO published a standard for preparation, presentation, and preservation of scientific and technical reports. Another standard for production of scientific and technical reports was published by Grey Literature International Steering Committee (GLISC) in 2007. GLISC refers to technical reports as documents included in the "wider category of Grey Literature (GL), defined as information produced on all levels of government, academics, business and industry in electronic and print formats not controlled by commercial publishing" (p. 1). In fact, as Miller and Selzer (1985) point out in their study of argument in ETRs, various sponsoring institutions and engineering companies have developed their own conventionalized contents of technical reports, which serve as outlines for writers of these reports.

The majority of textbooks on engineering writing provide information about the general structure and purposes for writing technical reports. However, such instructional materials focus on the overarching genre of technical report, without making distinctions among different types of technical reports. In fact, a variety of engineering documents can be classified under the general term *technical report*. Bowden (2004) lists 23 types of common reports, which could be classified by others as technical reports. To illustrate, reports such as comparative testing reports, explanatory reports, feasibility reports, research reports, scientific reports, student project reports, systems evaluation reports, and technological reports (Bowden, 2004) could potentially be included in the technical reports category because all these documents generally deal with technical information, involve problem solving, and follow the problem-solution pattern of organization. The following section presents a survey of research on the genre of ETR which may help us better understand this genre and thus better understand its sub-genres, including that of engineering design reports.

2.2.1 Studies Investigating Engineering Technical Reports

Despite the prominence and importance of ETRs as a genre in engineering, research examining this essential engineering genre is limited to several studies. Following Gosden's (1993, as cited in McKenna, 1997) framework for analysis of research articles, McKenna (1997) analyzed three engineering reports from a Hallidayan genre perspective and examined relationships between grammatical subject position and the theme of the sentence to draw conclusions about the nature of engineering discourse and provide recommendations for improving engineering report writing. The results led McKenna to conclude that interactive metafunction is less important in engineering reports than in research articles examined by Gosden because engineers do not need to position themselves within the discourse community, as their credentials are established when these engineers are commissioned to complete a report. Further findings of the study suggest that engineers frequently convert common entities, events, and processes into scientific concepts and principles thus differentiating themselves from people outside their professional community.

In another study examining the language of technical reports in engineering, Flowerdew (2004) compared key words of the problem-solution pattern in engineering apprentice and professional corpora (250,000 words each). Using the Keywords Tool in the WordSmith Tools software (Scott, 1996), the researcher identified and described the salient lexis for the problem-solution pattern. The second part of the study reports on the classification of the key words following the APPRAISAL framework developed by systemic-functional linguists for encoding evaluative lexis. The results revealed different patterns of use of evaluative lexis in the two corpora. The problem element in the professional corpus tends to favor evoking lexis (i.e., lexis that draws on ideational meaning to connote evaluation, such as in *cancer* or *pollution*) while the solution element tends to prefer inscribed lexis (i.e., lexis that is explicitly evaluative, as in *problem* or *drawback*). In contrast, in the student corpus, inscribed lexis appears to be related to the problem aspect and dominates the overall signaling of the problem-solution pattern. The study also revealed students' heavy reliance on superordinate terms, such as *problem* or *recommendations*, which the author related to the metalanguage provided in the assignment guidelines. Finally, the researcher highlighted the need to consider "context of situation" and "context of culture" when interpreting evaluative keyword lexis in engineering reports, as some vocabulary items could fill either the problem or solution slot, depending on the context.

Dalton (2008) explored some linguistic and organizational elements of a typical engineering document (memo report) produced by students in one of the engineering programs at the Petroleum Institute in Abu Dhabi, UAE. The researcher's goal was to describe some salient features that contribute to the document's level of success, or readability, as judged by the subject teacher grading the document. Eleven texts were analyzed according to specified linguistic features in addition to use, style, and organization. Successful application of these features was a factor in the response of the content teacher to the quality of the report. Another study carried out in an English as a Foreign Language (EFL) setting examined literature review sections of final-year project reports written by undergraduate engineering students in a Singapore university (Krishnan & Kathpalia, 2002). Ten final reports were analyzed from two main perspectives. The first was to determine the overall structure of the texts to see whether students recalled from prior training how literature review chapters are organized. The second was to examine strategies used by students to cope with the complex task of citing information from other sources. The results of the study showed that students typically can recall the generic structure of a literature review section from past training but tend to omit certain functional elements. Also, NNS engineering students in the study used various compensatory strategies to overcome the problem of repeating source text information verbatim.

Drawing on cognitive theories and text linguistics, Bartholomew (1993) described an organizing structure of technical reports in science and engineering. His research provides evidence of a conventionalized six-element structure, which can be characterized in a rule-governed way and which is recognized by experienced writers familiar with engineering discourse. The elements found in the study include introduction, scope, problem, solution, discussion, and conclusion. Although Bartholomew’s study is discussed here, it should be noted that his definition of the technical report genre is rather broad and thus his analysis was based on an assortment of 12 technical report texts that included examples of well-formed and ill-formed writing. These texts included scientific articles, installation procedures, medical self-care instructions, emerging technology reports, memos, a patent, an academic paper, a comic-book style quarterly shareholder's report from Marvel Comics, a parody letter report, and a Wall Street analyst's industry tracking report.

Marshall (1991) investigated the application of the genre-based approach to the teaching of technical report writing. The author points out that ESP educators should equip students with knowledge of formal schema required to produce reports; Marshall also emphasizes the importance of explicitly teaching the rhetorical structure of this genre to students, and demonstrates how a genre of feedback to written reports can be created and implemented in teaching of technical writing. To Marshall, explicitly teaching report writing goes beyond showing students how to present information effectively and serves as a means to facilitate development of scientific thinking.

Other papers discussing ETRs, while drawing on the ESP tradition in that they present typical structures of these documents, do not constitute empirical studies. Rather, these papers can be viewed as writing guides or tutorials for both engineering students and their writing teachers (Akorede, 2009; Baake, 2007; Kotecha, 1991; Motley & Nauda, 1988; Weinstein, 1987). Further, Flowerdew (2000) proposed the use of a genre-based framework, in the ESP genre tradition, for teaching the organizational structure of engineering technical reports to students. The results of her analysis of 15 engineering undergraduate technical reports revealed that the problem-solution pattern is prevalent in key sections of these reports, and should therefore also be considered in teaching this genre. Specific exercises for sensitizing students to the genre structure and the problem-solution pattern are then suggested by the researcher.

Another study that examined engineering technical reports from a pedagogical point of view involved a small-scale investigation of ETRs written by NS and NNS undergraduate engineering students (O'Brien, 2000). These reports were analyzed to determine whether student language proficiency, demographic factors, and other non-linguistic factors had an impact on the assessment of students' ETRs by professional engineers. The results of the study revealed that NNS students tended to compensate their conceptual and linguistic weaknesses by mastering the structural organization of the report. Demographic and other non-linguistic factors were also found to influence the acceptability of these ETRs evaluated by professional engineers.

In sixteen case studies, Sloat (1994) examined factors that either promote or hinder workplace writing among engineering students enrolled in technical report writing classes. Sloat investigated the extent to which a workplace writing environment, which instructors believe they create, is actually enacted in the classroom. Sloat also explored the differences in intended and actual learning outcomes between instructors and students. The researcher concluded that writing tasks did not reflect an authentic workplace writing situation. In fact, the writing task became a school-based exercise where students learned to provide the correct textual format to meet teachers' expectations. These findings further emphasize the difficulty of enacting authentic workplace writing contexts within academic environments, and prompt educators to be aware of their real teaching and learning agendas.

These studies show that most research on ETRs is concerned with student writing, not writing by practicing engineers. In addition, most studies do not define the genre that they call technical reports, so it is not entirely clear whether the ETRs studied included a mixture of reporting genres or just one type. Differentiating among the various sub-genres within ETRs, however, is important. As discussed above, despite some overlap in general communicative purposes and content among all technical reports, specific sub-genres within the ETR genre may have different specific communicative purposes, which ultimately may have an effect on these documents' rhetorical organization and language use. The following section, which focuses on engineering design reports (EDRs), one such sub-genre, describes EDRs based on information found in several engineering design and engineering writing textbooks. It then differentiates between engineering design reports and other engineering reports within ETRs, such as engineering research reports, and finally defines an EDR.

2.3. Engineering Design Reports

The results of a small-scale pilot study[2] (Poltavtchenko, 2010a) show that engineering design reports (EDRs) are a commonly written disciplinary genre recognized by engineering faculty and professionals alike, though the frequency and purposes for writing EDRs may vary in academic and professional settings. The importance of the EDR genre is further highlighted by the emphasis that ABET places on the assessment of communication skills in integrated, project-based contexts. As a result, many engineering classes require students to prepare formal written reports and oral presentations as part of their design projects. In fact, such formal reports can be required of engineering students as early as their freshman year (Miller, Bausser, & Fentiman, 1998). With the current demand for design classes and written design reports being required in most of them, there is a clear need for a better understanding of how these documents are organized and what characterizes a well-written professional engineering design report.

To prepare engineering undergraduates to become more successful communicators in their engineering courses and future workplaces, it is imperative to provide these students with effective instruction on this crucial engineering genre. The effectiveness of such instruction will depend directly on the soundness of the materials used by writing instructors, which need to be based on solid empirical findings. Because the engineering design process is at the heart of this genre, before an EDR as a genre can be defined, it needs to be contextualized within the disciplinary practices of the

[2] Poltavtchenko (2010a) investigated what she perceived to be ETRs. In Poltavtchenko (2010b), carried out for her qualifying exam, it was discovered that the genre examined in Poltavtchenko (2010a) was, in fact, the EDR.

engineering community. This can be accomplished by describing engineering design and the role EDRs play in this process.

2.3.1 Engineering Design Process

According to Gassert and Enderle (2008), the ability to design helps determine "whether [an engineering] graduate is truly prepared to practice engineering" (p. 81). It is not surprising then that ABET criteria require that all engineering graduates have a major design experience and that academic programs demonstrate that each of their graduates has been successful (ABET, 2013). Different definitions of engineering design exist (Dym, 1994; Eder & Hosnedl, 2008; Eggert, 2005; Hyman, 2003; Pahl et al., 2007), with many engineering textbooks citing a definition put forth by ABET (Eide et al., 2002; Ertas & Jones, 1996). Table 2.2 briefly illustrates how engineers define this process. Although definitions can differ, most engineering professionals agree that engineering design is a creative, iterative, and methodical decision-making process in which an engineer optimally applies previously learned knowledge and skills to design an artifact that meets a stated objective.

Table 2.2 Descriptions of the engineering design process relevant for defining EDRs as a genre

Descriptions of the engineering design process	Features that may be relevant for defining EDRs
1) Engineering design is the process of devising a system, component, or process to meet desired needs. It is a decision-making process (often iterative), in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing, and evaluation. The engineering design component of a curriculum must include most of the following features: development of student creativity, use of open-ended problems, development and use of modern design theory and methodology, formation of design problem statements and specifications, consideration of alternative solutions, feasibility considerations, production processes, concurrent engineering design, and detailed descriptions. Further, it is essential to include a variety of realistic constraints such as economic factors, safety, reliability, aesthetics, ethics, and social impact (ABET definition of engineering design, as cited in Ertas & Jones, 1996, p. 2).	a) *Development* of a system, component, or process to *meet desired needs* b) Formation of design problem statements and specifications c) Establishment of *objectives* and criteria for the *artifact* d) Consideration of *alternative solutions*, feasibility considerations e) Inclusion of realistic constraints f) Construction, testing, and evaluation of the artifact g) *Description* of production processes
2) Design is the activity in which engineers accomplish the preceding task, usually by responding to a design imperative for the required task. The design imperative is the result of a problem definition …. The end result of the engineering design process is a specifications set from which a machine, process, or system may be built and operated to meet the original need (Shigley, Mischke, & Brown, 2004, p. 1.1).	a) Response to a problem definition for the required task b) The end result is a *specifications* set from which a machine, process, or system may be built c) Meeting the *original need*
3) Engineering design is the systematic, intelligent generation and evaluation of specifications for artifacts whose form and function achieve stated objectives and satisfy specified constraints (Dym, 1994, p. 17).	a) Systematic, intelligent generation and evaluation of specifications for artifacts b) Form and function of artifacts achieve objectives and satisfy specified constraints

Descriptions of the engineering design process	Features that may be relevant for defining EDRs
4) Products are artifacts conceived, produced, transacted and used by people because of their properties and the functions they may perform. Product design is the process of devising and laying down the plans that are needed for the manufacturing of a product. … In modern industrial production the makers of a product are normally not the same people as its designers. In a factory products are manufactured according to a design that has been prepared by the design department or by an external design office. … As such, product design is basically devising and describing the geometry, materials and production techniques of a new product (Roozenburg & Eekels, 1995, p. 3).	a) Development of the *plans* that are needed for the manufacturing of the product b) Process of devising and describing the geometry, materials, and production techniques of a new product

Textbooks on engineering design (Dominick et al., 2001; Dym, 1994; Eder & Hosnedl, 2008; Eide et al., 2002; Ertas & Jones, 1996; Hales, 1993; Heisler, 1998; Jenkinson & Marchman, 2003; Khan & Raouf, 2006; Pahl et al., 2007; Towler & Sinnott, 2008; Wasson, 2006) list a number of different phases involved in engineering design projects. These phases range in number and scope, with fewer or more steps listed for each. Despite these different depictions of the engineering design process, all design projects start with a clarification phase in which an engineer identifies a need and clearly defines a problem. All design projects also go through the following three phases of (a) conceptual design, (b) embodiment or preliminary design, and (c) detailed design. Table 2.3 summarizes these major phases and makes connections to various steps involved in the design project, as identified above.

As can be seen in Table 2.3, in the beginning of a design project, the need for the project might be expressed in very general terms; however, as the project progresses, each of its phases adds an increased level of detail about an artifact until it can be built. Importantly, in a design project, the engineer knows with certainty whether or not the design product meets predetermined specifications for the project and thus knows whether a project has been successful or not. Finally, all design projects have a communication component that runs throughout the project, and the *documentation* of the designed artifact is typically listed as the last step in most engineering textbooks (Dominick et al., 2001; Dym, 1994; Eide et al., 2002; Pahl et al., 2007). It should be noted, however, that different engineering disciplines and industries may have their own standards for design documentation.

Importantly, in some professional and academic settings, the design process and its outcomes are expected to be documented in a formal report written at the end of the design project, the engineering design report (EDR). For example, in academic settings, most design classes require students to document each phase of their design projects, resulting in the final design report typically completed at the end of the semester. In professional settings, governmental institutions sponsoring various engineering research and development efforts typically require that principal investigators submit EDRs detailing their research and design projects.

Table 2.3 Major stages and steps of the engineering design process

Major stages of engineering design (according to Dym, 1994)	Steps that might be included, based on information from other textbooks on engineering design
Clarification phase • Identification of a need and clear definition of a problem	○ Defining the problem (Dominick et al., 2001) ○ Clarifying the client's requirements (Dym, 1994) ○ Identifying the environment (Dym, 1994) ○ Identifying the need, defining the problem, searching for necessary information, considering constraints, formulating criteria (Eide et al., 2002)
Conceptual design • Analysis of different concepts that can be used to solve a particular problem • Focus on function of the artifact	○ Formulating solutions (Dominick et al., 2001) ○ Considering alternative solutions (Eide et al., 2002)
Embodiment or preliminary design • Selection of the major subsystems based on performance specifications and operating requirements • Extensive use of calculations, modeling, and analysis • Optimization of the preliminary design	○ Developing models and prototypes (Dominick et al., 2001) ○ Analyzing or modeling the behavior of an artifact (Dym, 1994) ○ Identifying constraints, including manufacturing, economic, marketing, and other constraints (Dym, 1994) ○ Analyzing data, making decisions (Eide et al., 2002)
Detailed design • Testing, evaluation, debugging • Detailed documentation of the designed artifact	○ Testing and evaluating the proposed design(s) (Dym, 1994) ○ Refining and optimizing the design (Dym, 1994) ○ Presenting and implementing the design (Dominick et al., 2001) ○ Documenting the completed design for the client (Dym, 1994) ○ Writing specification, communicating the design (Eide et al., 2002)

Some institutions call these engineering documents final reports; others call them technical reports, research reports, or design reports. Although sometimes these different labels reflect different engineering genres, oftentimes the different labels refer to a single genre (Glushko & McGrath, 2005). This inconsistency in naming particular documents presents a considerable challenge to someone who seeks to clearly define a previously inadequately described and studied genre. Further, as both design and research reports belong to the same overarching genre of engineering technical reports, it is expected that there will be some overlap among their rhetorical and linguistic features. Because there could be considerable overlap among these documents, their rhetorical, linguistic, and other non-linguistic differences should be discussed in detail so that they can be clearly differentiated. Before the differences between these reporting sub-genres can be discussed, the process of engineering research needs to be defined better because a clear understanding of what the engineering research process entails will help differentiate between engineering research and design reports.

In general, similar to research in other disciplines, engineering research has an open-ended goal and is exploratory in nature. On the other hand, design projects consider alternative solutions and select an optimal one for a set of predefined requirements. Further, while it is generally easy to say whether a design project was successful with certainty because there is a clear outcome that satisfies a set of predetermined specifications and requirements, it is typically difficult to determine whether the outcome of a particular research project has been successful because there is no clear way to measure it. It is also important to note that both design and research projects entail documentation that accompanies these processes.

Typically, details about research projects are disseminated to the scientific community through research articles published in professional journals. However, when research projects are carried out for various governmental institutions, the results of these scientific endeavors are typically distributed through publicly available databases of governmental technical reports. These technical report databases contain a variety of documents, including research reports and design reports, which makes it imperative to look at these documents more closely in order to devise a clear-cut way to differentiate between them. To help clarify boundaries between engineering design and research reports, the following section defines the term *engineering design report* and describes its prominent characteristics.

2.3.2 Characteristics of Engineering Design Reports

Not many textbooks specifically describe engineering design reports (EDRs) (cf. Eide et al., 2002; Dominick et al., 2001; Hordemann, 2003; Jenkinson & Marchman, 2003; Silyn-Roberts, 2000). Those that do describe them do not emphasize the discourse structures or linguistic choices used by the writers of such reports. To date, there are no empirical studies that confirm the general statements made by various textbook writers about the discourse structure of this important genre. In addition, it is not known if and how the discourse structure of and linguistic choices made in EDRs written in the workplace are different from those of EDRs written in academia. The present dissertation study seeks to establish empirically a prototypical discourse structure of EDRs and describe its major variations. In addition, this research examines the linguistic choices found in major organizational units of EDRs written by engineering professionals. However, before such an empirical investigation can be carried out, it is necessary to describe thoroughly and define clearly the genre of EDR so that these reports can be differentiated from other types of technical reports.

Textbook writers who discuss EDRs agree, at the most general level, that these reports consist of three major parts: Front matter, body of the report, and back matter.

The specific details for each of these major parts differ slightly from one textbook depiction to the next. In the real world, these parts of the EDR would likely depend on what was requested by a client in professional settings or by an engineering faculty in academic settings. In general, front matter includes the following elements: Title page, abstract or executive summary, table of contents, and list of figures and tables. Back matter generally consists of references and various appendices. The front matter and the back matter for most reporting genres, however, appear to have many similarities and, therefore, cannot serve to differentiate between EDRs and other engineering reports, including research reports.

The most important part of the engineering design report, the body of the report, is typically defined by textbook writers in rather general terms, with most authors stating that this part will start with an introduction (Sorby & Bulleit, 2006), which would most likely include a problem statement and background information that explains the cause of the problem and the reason for seeking a practical solution (Dominic et al., 2001; Hordemann, 2003). The introduction may also briefly describe the purpose of the report and its scope or limitations (Finkelstein, 2005). The EDR introduction also most likely includes criteria set for deciding on an adequate solution (Silyn-Roberts, 2000) and a plan for attacking and solving the problem (Eide et al., 2002). It is also possible that the introductory section establishes the relevance of the work and put one's design into a broader context by identifying other relevant work and information (Jenkinson & Marchman, 2003). Finally, the introduction might conclude with an overview of the structure of the report (Jenkinson & Marchman, 2003). Table 2.4 displays different types of information that textbook writers suggest should be included in introductions of EDRs.

As can be seen, the most frequently suggested content of the design-report introduction consists of a problem statement, necessary background information, and the purpose of the project.

Table 2.4 Content of EDR introductions

Suggested content	Dominic et al. (2001)	Eide et al. (2002)	Finkelstein (2005)	Hordemann (2003)	Jenkinson & Marchman (2003)	Silyn-Roberts (2000)	Sorby & Bulleit (2006)
Problem statement	✓	✓	✓	✓		✓	✓
Background information	✓	✓	✓	✓	✓		✓
Purpose of the project	✓		✓	✓			✓
Possible solutions/ Plan for attacking the problem		✓				✓	✓
Set of requirements for solutions	✓			✓		✓	
Constraints put on the design	✓						
Scope of the project			✓				
Overview of the report structure					✓		

The next sections in the body of an EDR describe the engineer's or engineering team's effort on the project. The progression of these sections seems to correspond to the sequence of major phases of the engineering design project, and focuses on conceptual design, embodiment and preliminary designs, and detailed designs. The sequence of EDR sections also resembles the typical discourse structure of other technical reports, in which methodology is first described, followed by results and discussion sections. The descriptions of these sections found in the textbooks show that no clear consensus exists among textbook writers as to what specific kinds of information and in which order they should be covered in these sections of the engineering design report. The textbook authors do agree on the fact that information should logically describe the design process. Further, the overly general nature of such descriptions most certainly is not helpful to engineering students who are just starting to be socialized into their disciplinary culture and beginning to learn discipline-specific genres.

After design methodologies and results of necessary analyses and tests are discussed, the Discussion section may be included to describe specific features of the design, problems encountered during the design process, and unusual aspects of the design (Sorby & Bulleit, 2006). This section should provide support for conclusions and recommendations made at the end of the body of the engineering design report. The *Discussion* section may also be combined with the Results section, or it can be omitted when discussion is integrated throughout the report. The body of EDRs then typically ends with conclusions and recommendations, which could be presented in one section (Dominick et al., 2001; Eide et al., 2002) or separately (Jenkinson & Marchman, 2003; Sorby & Bulleit, 2006). Table 2.5 summarizes the main findings about the structure and content of EDRs and demonstrates how these structural units correspond to the stages and steps of the engineering design process.

This discussion of textbook recommendations suggests that textbook guidelines are rather flexible, allowing for some variation across projects and individual writers. Certain EDR content is depicted as belonging to a specific section within an EDR because it corresponds to a particular stage of the engineering design process. In reality, however, that content may appear in another major organizational unit. In addition, even though a particular unit may focus on design methodology, it may not be labeled the Method or Methodology section but rather its heading may reflect specific work on the design of an artifact (e.g., Hardware Design) and it may contain embedded subsections. Certainly, such flexibility in discourse structure and the varied descriptions of the content and structure of EDRs might be very confusing to engineering undergraduates.

Despite this flexibility, the review of the literature on EDRs indicates that this is a recognized genre in engineering and that it reflects specific disciplinary activities and, according to textbooks, has relatively established structure. Table 2.5 shows the overall structure of EDRs, which, according to textbooks, seems to follow a general Introduction – Methods – Results – Discussion (IMRD) format and closely corresponds to the major phases of the engineering design process. The major difference between EDRs and other types of technical reports, therefore, seems to be related to the activities discussed within design reports. Specifically, their discerning characteristic is their focus on the design of a specific artifact that needs to satisfy specific requirements determined before the beginning of design activities. These reports also describe the major phases of the engineering design process, including conceptualizing alternative designs, selecting the best preliminary design(s), optimizing the design, and describing the resulting artifact.

Based on the information found on the EDR genre and on the previous discussion of how this genre may be different from other types of technical reports (e.g., research reports), the following working definition of an engineering design report has been developed:

An engineering design report (EDR) is a formal document that is produced in response to a specific need and written after a design project has been completed. EDRs typically include information about (a) a specific problem being solved, (b) predetermined requirements for an artifact being designed to solve the problem, (c) two or more possible solutions for the problem, (d) specific design constraints, (e) the process of selection of an optimal solution for the choices available, (f) all useful technical work completed in the course of the design process, and (g) a thorough description of the designed artifact. It is important to note that, depending on the engineering discipline and particular project, the artifact can be an actual constructed prototype or a conceptual design, or design that exists only on paper. In both cases, the designed artifact needs to satisfy specific requirements determined before the beginning of design activities.

The sequence of this information closely corresponds to the sequence of major phases of the engineering design process and is likely to be dependent on both design project and individual writer(s). Similar to other reporting genres, EDRs may include research about technical concepts involved in the design process and typically present graphical depictions of designs and data. Further, similar to engineering technical reports, EDRs are written to ensure (a) the accountability of the engineer(s) who designed artifact(s) and (b) repeatability of their designs. Thus, EDRs are generally written for the following purposes: (a) to give an overview of how an engineering design was accomplished, (b) to provide a thorough description of all useful technical work completed for the design project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a design project.

Table 2.5 General structure and content of EDRs and corresponding stages of the design process according to textbooks

Major parts	Major sections and their contents	Corresponding major stages and steps of the engineering design process
Front matter	Title Page Abstract or Executive Summary TOC and List of Figures and Tables	
Body	**Introduction** • Problem statement • Background information • Purpose of the project • Possible solutions/Plan for attacking the problem • Scope of the project • Overview of the report structure	**<u>Clarification phase</u>** • Defining the problem (Dominick et al., 2001) • Clarifying the client's requirements (Dym, 1994) • Identifying the environment (Dym, 1994) • Identifying the need, defining the problem, searching for necessary information, considering constraints, formulating criteria (Eide et al., 2002)
	Methods • Requirements and specifications of the design solutions • Constraints • Alternatives available • Research completed, theories used, assumptions made, procedures and processes used to develop the design • Work breakdown: What was done when, why, and how • Team dynamics	**<u>Conceptual design</u>** • Formulating solutions (Dominick et al., 2001) • Considering alternative solutions (Eide et al., 2002) **<u>Embodiment or preliminary design</u>** • Developing models and prototypes (Dominick et al., 2001) • Analyzing or modeling the behavior of an artifact (Dym, 1994) • Identifying constraints, including manufacturing, economic, marketing, and other (Dym, 1994) • Analyzing data, making decisions (Eide et al., 2002)
	Results • Test and analyses results • Troubleshooting and remediation efforts • Optimization efforts **Discussion** • Important specific features or unusual aspects of the design • Problems encountered **Conclusion** • Details about artifact that was designed • Evaluation of the success of the project in terms of meeting the original criteria and constraints **Recommendations**	**<u>Detailed design</u>** • Testing and evaluating the proposed design(s) (Dym, 1994) • Refining and optimizing the design (Dym, 1994) • Presenting and implementing the design (Dominick et al., 2001) • Documenting the completed design for the client (Dym, 1994) • Writing specification, communicating the design (Eide et al., 2002)
Back matter	References Appendices	• Discipline or company-dependent • Project-dependent

2.3.3 Studies Investigating Engineering Design Reports

Despite the prominence and importance of EDRs as a genre in engineering, research examining this essential engineering genre has been extremely limited. Discussing reforms in engineering education associated with ABET accreditation changes, Brinkman and van der Geest (2003) focus on the shift from traditional stand-alone courses in technical communication for engineering students to communication components integrated into engineering courses and design projects. While the main foci of their discussion are the challenges for assessment of students' communication competence within integrated communicative training, the authors discuss the emphasis placed by ABET on communication about design projects.

The authors outline four layers of communication competence that should be assessed in these new circumstances. Their model of communication competence consists of the following layers: (a) text craftsmanship, (b) genre competence, (c) strategic communicative competence, and (d) feedback competence. The text craftsmanship layer of this communication competence model refers to the use of standard grammar, spelling, and clarity of organization. The genre competence layer then is associated with knowing conventions of specific genres, including acceptable rhetorical moves, order and format of text parts, layout, and quotations. Strategic communicative competence relates to the belief in the strategic behavior(s) of effective communicators. Specifically, the authors maintain that engineering students should "be able to make and explain layer 1 and layer 2 decisions from a strategic, rhetorical point of view" (p. 71). Finally, because engineers seldom work alone, the fourth layer of the model refers to the students' ability to be effective team members by demonstrating competence in giving feedback to others. Although this model can be applied to a variety of genres in engineering, the emphasis on design projects and communicative training within such projects may imply that the layers of the model were envisioned with engineering design reports in mind.

Another EDR genre study also focuses on assessment of student writing in engineering design courses. Miller et al. (1998) report on a year-long case study in which commenting styles of an experienced engineering professor and technical writing teachers were compared. Specifically, comments of the engineering professor on design reports written in an introductory engineering class were compared to the commenting style of technical writing teachers, as reported by previous research. The differences in these commenting styles, specifically that engineering faculty provide more directive comments, were attributed to the conventions of the design report genre. Explaining the differences in commenting styles, the authors list several characteristics of design reports that they believe led to the highly directive comments of the engineering professor. These characteristics are listed below:

- A non-linear, hypertextual form in which the reader's navigation is guided by visual cues.
- The expectation that readers will often not read the document entirely, but use it as a reference tool for selected information.
- The expectation of divided readership, where some readers will only read linguistic elements of the document, and some only visual elements.
- The extensive use of visuals.
- The exclusive or partial use of visuals as a form of invention and prewriting. (p. 459)

The studies conducted by Brinkman and van der Geest (2003) and Miller et al. (1998) provide invaluable information on the much overlooked but important genre of engineering design reports, though EDRs in these two cases are discussed only in terms of assessment. The studies do not investigate the discourse structures or linguistic choices associated with EDRs. Further, both studies focus only on ERDs written in academic settings, which does not shed light on how this genre is organized or used in the workplace by practicing engineers. The present dissertation research fills this gap by empirically examining both discourse structures and linguistic choices of professional EDRs. The study also compares core lexico-grammatical features of EDRs written in professional and academic settings. The results of this dissertation research thus could be used in the future to inform instructional materials designed for engineering students learning how to write EDRs. To better understand EDRs, it may be necessary to use several complementary methods of analysis. The following section discusses two approaches to discourse analysis and argues for the need to use both in the present study. Previous studies that used similar approaches are then surveyed to show their various uses.

2.4. The Need for Both Genre- and Register-Based Approaches to Discourse Analysis

Recently the need for more comprehensive ways to analyze discourse (i.e., ways that include both genre-based and register-based approaches to analysis) was argued (Biber & Jones, 2005; Charles, 2007; Flowerdew, 2008; Upton & Connor, 2001). Traditionally, studies that explored how communicative purposes are realized through systematic structuring adopted the genre approach to discourse analysis. On the other hand, studies that primarily focused on lexico-grammatical features used corpus-based methodologies and often involved register, rather than genre, analysis. According to Biber and Conrad (2009), genre-based and register-based approaches to discourse analysis are different in terms of the (a) texts chosen for analysis, (b) linguistic characteristics selected for analysis, (c) distribution of these linguistic characteristics, and

(d) interpretation of linguistic differences observed in the texts. Thus, it is important to differentiate between the terms *genre* and *register*.

Following Biber, Connor, and Upton (2007) and Biber and Conrad (2009), the present study uses the term *genre* when focusing on the organizational structure and conventional features of the whole text. In terms of linguistic characteristics, genre-based analysis typically centers on those linguistic characteristics that help to structure complete texts. Therefore, genre-based studies are rooted in the analysis of complete texts, often focusing on their rhetorical organization. The linguistic features considered for such analyses are typically not functional, but rather are conventionally associated with a particular genre. They are not pervasive and may only occur once in a text, often at a structural boundary. For example, it is expected that a formal business letter would have a greeting in the beginning, such as "Dear Mr. Smith" and a closing line like "Sincerely."

The term *register*, on the other hand, is used to refer to "a language variety associated with both a particular situation of use and with pervasive linguistic features that serve important functions within that situation of use" (Biber & Conrad, 2009, p. 31). As this definition shows, a register-based analysis is distinct from a genre approach to text analysis because it focuses on the description of frequent lexical and grammatical characteristics of texts. Thus, the texts used for this type of analysis can be either complete texts or text excerpts. Another essential component of the register analysis involves description of situational contexts, or characteristics, associated with a particular register (e.g., communicative purpose, participants). Most importantly, when considered from a register perspective, linguistic features are always viewed as functional. In other words, these features occur because they are appropriate for the situational context of the register. The third component of the register description then involves a functional analysis that connects the linguistic analysis with situational characteristics of the register.

These two perspectives on discourse analysis also differ with respect to the methods of data analysis used by their advocates. In particular, genre-based studies (e.g., Bhatia, 1993; Martin, 1992; Samraj, 2002; Stoller & Robinson, 2013; Swales, 1990, 2004; Williams, 1999) approach discourse analysis from top-down, emphasizing the "integrity" of the text, that is, they focus on the rhetorical organization of the texts. These studies involve a close analysis of the discourse structure and therefore typically entail qualitative analysis. One example of such an approach is Swales's (1990) move analysis briefly discussed above.

Because of its labor-intensive nature, until recently, genre-based analysis was applied only to a small sample of texts (Anthony, 1999; McKenna, 1997; Williams, 1999), making it hard to generalize its findings. Additional criticisms of this approach are linked to the process of coding of move types and the focus of the analysis itself. In particular, move boundaries are semantically determined; therefore, lack of explicit protocols for identification of move boundaries often reflects subjective judgments, which leads to questions about the reliability and validity of the analysis (Kanoksilapatham, 2005; Paltridge, 1994). Finally, although some studies have applied genre analysis to full genres (Kanoksilapatham, 2005; Luzón, 2002; Samraj & Monk, 2008; Stoller & Robinson, 2013), many move analysis studies have focused only on individual sections of a genre (often the research article). These investigations include analyses of research article abstracts (Promsin, 2006), introductions (Anthony, 1999;

Kanoksilapatham, 2012; Samraj, 2002; Swales, 1990), literature reviews (Kwan, 2006), methods sections (Bruce, 2008), discussion sections (Hopkins & Dudley-Evans, 1988), results and conclusions (Brett, 1994; Yang & Allison, 2003), and acknowledgements (Hyland, 2004), thus providing an incomplete rhetorical description of the texts.

On the other hand, the register-based approach to discourse analysis typically relies on corpus-based methodologies. Corpus linguistics tends to use a representative sample of texts and entails quantitative analysis. Thus, corpus-based methodology allows for the empirical investigation of linguistic aspects of particular kinds of language through a computerized analysis of large, systematic and representative collections of texts (i.e., corpora). The use of corpus-based methodology makes it possible to analyze spoken and written discourse in considerable detail and identify common and generalizable linguistic patterns that are based on actual patterns of use, not broad generalizations or personal intuitions (Orr, 2006; Stoller et al., 2005). For example, the *Longman Grammar of Spoken and Written English* (Biber, Johansson, Leech, Conrad, & Finegan, 1999) examines lexico-grammatical features of written and spoken registers of American and British English and presents corpus findings that help explain the functional parameters of language based on frequencies and statistical patterns of usage. While some studies investigate multiple linguistic features or patterns of their co-occurrence in spoken (Friginal, 2008; Helt, 2001; Quaglio, 2004) and written (Biber, 2006a; Biber & Gray, 2010; Conrad, 1996, 2001) registers, other studies may focus on a specific linguistic feature or groups of features in a register, such as compressed noun phrases in newspaper discourse (Biber, 2003), features of accommodation and involvement in class lectures (Barbieri, 2008), modal use in university registers (Keck & Biber, 2004), or stance expressions in classroom management (Biber, 2006b).

2.4.1 Studies Using Both Genre- and Register-Based Approaches

As can be seen from these brief descriptions of two different methods of data analysis, both genre-based and register-based approaches to discourse analysis can be considerably strengthened if applied concurrently. A genre-based approach can help explain rhetorical aspects of text organization while a register-based approach that employs a corpus-based methodology can shed light on particular linguistic choices within this text structure. However, to date there are only a few studies that use both approaches to investigate disciplinary genres (Biber, Connor, Upton, Anthony, & Gladkov, 2007; Biber, Connor, Upton, & Jones, 2007; Biber & Jones, 2005; Charles, 2007; Csomay, 2002, 2007; Kanoksilapatham, 2003, 2005, 2007; Upton & Connor, 2001), and engineering discourse in particular (Flowerdew, 2008).

For example, acknowledging the different foci and limitations of Swales's (1990) move analysis and Biber's (1988) multidimensional analysis, Kanoksilapatham (2003, 2007) used these two prominent approaches to demystify scientific discourse by analyzing 60 research articles from the top five journals in biochemistry. The researcher first carried out the move analysis to identify the rhetorical organization of the research articles in her corpus. Then she used corpus-based MD analysis to show how moves vary in terms of the co-occurrence of a number of linguistic features. The study not only provided a basic template of the structure of biochemistry research articles, but also presented sets of linguistic features commonly used to express particular communicative purposes in these articles.

A different way of using both corpus linguistic and discourse analytic approaches was taken in Biber et al. (2007) and Biber and Jones (2005). To analyze the discourse patterns in a large corpus of biology research articles, these studies first used computational techniques to identify vocabulary-based discourse units (VBDUs) and then determined how these VBDUs differ linguistically by means of MD analysis. After the basic VBDUs were described, the researchers illustrated how the internal structure of biology research articles can be described as a sequence of discourse units with varying linguistic patterns.

Notably, Flowerdew (2008) analyzed engineering technical reports written by professional engineers and engineering students and used a genre-based approach as well as corpus-based methodologies in her study. Similar to Kanoksilapatham's studies (2003, 2007), Flowerdew first identified the rhetorical structure of the texts in her corpora and then analyzed their linguistic features. However, unlike research by Kanoksilapatham, Flowerdew's study was based on the systemic-functional approach to genre analysis, not Swales's move analysis. Specifically, she used key word analysis of the two corpora of technical reports to determine whether these key words signal a problem-solution rhetorical pattern. She then used corpus-based methodologies to carry out a phraseological analysis of signals for the problem and solution elements in professional and student reports. Pedagogical implications based on the study's findings were then discussed.

Despite the recognized benefits of using both genre-based and register-based approaches to discourse analysis, investigations in this vein started only recently and remain limited; thus, there is a need for research that provides a more comprehensive picture of the discourse that is being analyzed by integrating results from both of these analyses.

2.4.2 Discourse Analytic and Corpus Linguistic Studies of Engineering Written Discourse

Studies investigating engineering discourse from various genre-based perspectives were discussed in Sections 2.1.2 and 2.1.3. In addition, Sections 2.2.1 and 2.3.3 discussed previous genre-based research of engineering technical and design reports. This section, therefore, focuses only on corpus linguistic investigations of engineering written discourse and covers studies that were not discussed in detail in previous sections.

Few corpus-based studies have investigated engineering written discourse. Some notable exceptions include Mudraya (2004a) who has reported the development of the Student Engineering English Corpus (SEEC). Her corpus consisted of texts from English-language textbooks in basic engineering disciplines that were intended to establish a representative corpus of engineering lexis. Based on the results of her later corpus-based study, the researcher (Mudraya, 2004b, 2006) argued for the integration of the lexical approach with a data-driven corpus-based methodology to be used in English classes for engineering students. The results of her studies revealed the importance of sub-technical vocabulary (i.e., words that are used in general English but acquire a specialized meaning in a particular disciplinary discourse), and formulaic multi-word collocations for future engineers.

Mudraya’s findings resonate with those described in Ward (2007), who explored how collocations relate to lexical technicality in engineering texts. Examining the lexical characteristics of undergraduate textbooks in five engineering disciplines, Ward found that collocations consisting of complex noun phrases are a pervading feature of engineering text. Ward also discovered that while these collocations are highly discipline-specific, the individual words that they are composed of are not. Drawing on these results, Ward (2009) examines vocabulary in random passages from 25 engineering textbooks. The textbooks were selected after consultations with engineering faculty from five disciplines and used to compile a corpus of 271,000 words. The result of his corpus-based analysis is a word list for less proficient foundation engineering undergraduates that (a) assumes little lexical or grammatical knowledge, (b) can be used by learners with low proficiency in English, and (c) can be applied to a number of engineering disciplines.

The few studies discussed above represent corpus-based investigations that make use of corpora that consist of texts produced by engineering textbook writers. Even fewer corpus-based studies were found that report analyses using engineering students' writing. In fact, besides Promsin's (2006) study of textual organization of abstracts in engineering Master's theses (discussed above), only one other study was found. In a small corpus of 17 research articles and nine research theses from the fields of electronic and chemical engineering, Koutsantoni (2006) examined differences in the density and function of hedges in these two genres, indicating that engineering students writing theses hedge more than expert professional authors do in research articles. Students also tend to avoid taking personal responsibility for their claims, as opposed to expert writers who frequently use personally attributed hedges.

Finally, one additional recent corpus-based study examined the language of engineering technical reports. Luzón (2009) studied the discourse functions of the pronoun *we* in a corpus of 55 reports written by Spanish-speaking engineering students.

The results of her analysis show that these students lack an understanding of ways in which expert writers use these pronouns to construct their authorial identities as knowledgeable members of the community. Students are largely unaware of the conventionalized use of phraseological patterns involving *we* to perform specific functions in academic genres.

2.5. Summary

As this literature review demonstrates, research investigating discourse structures and linguistic features of engineering written discourse, and those of engineering design reports (EDRs) in particular, has been limited. Research investigating EDRs examined this prominent disciplinary genre only in academic settings and for the purposes of student assessment. As can be seen, studies of EDRs are scarce in general, and research employing both genre- and register-based approaches to the analysis of this crucial genre cannot be found.

The present dissertation study fills this gap by using both genre-based and register-based approaches to examine professional EDRs. Specifically, the present dissertation research examines and compares core lexico-grammatical features and linguistic features associated with grammatical complexity in EDRs written in professional and academic settings. Further, in providing a rich description of the EDR genre, the study includes both text-internal and text-external factors. Finally, the present study draws on the ESP tradition to genre analysis to determine the typical discourse structure of EDRs written by practicing engineers. The study then uses copus-based methodologies to examine core lexico-grammatical features associated with major organizational units of professional EDRs.

2.6. Statement of Purpose

As the literature reviewed above shows, research on engineering written discourse remains limited. The present study is intended to improve our understanding of engineering design reports (EDRs) and ultimately provide support for engineering students learning to write in this disciplinary genre. Because engineering design reports are frequently written by professional engineers and engineering students, the results of the study may have pedagogical implications for teaching features of professional engineering written discourse, with an emphasis on the design report, to students majoring in engineering.

Thus, the goals of the study are to examine and compare linguistic features of EDRs written in professional and academic settings. To investigate this crucial engineering genre even further and provide a more detailed description of effective EDRs, the study seeks to (a) determine common organizational units and the acceptable range of structural variations within professional EDRs and (b) identify linguistic features associated with specific organizational units within professional EDRs. The results of the study then may be used in the future to inform pedagogical materials designed for engineering students and thus help narrow the gap between students' preparation and professional requirements for succeeding in the workplace.

To achieve its goals, the present dissertation research examines and compares core lexico-grammatical features and linguistic features associated with grammatical complexity in student and professional EDRs. Further, to explore how and why linguistic features are used in professional and student EDRs, the study examines situational characteristics of EDRs written by professional and student writers. To determine the conventional rhetorical structure of effective EDRs, the study then draws on the ESP tradition to genre analysis to determine the typical discourse structure of EDRs written by practicing engineers. Finally, the study uses corpus-based methodologies to examine core lexico-grammatical features of major organizational units of professional EDRs.

2.7. Research Questions

The present dissertation research seeks to examine and compare core lexico-grammatical features and linguistic features associated with grammatical complexity in EDRs written by practicing engineers in professional workplace settings and those produced by students in upper-division engineering courses. To further investigate the EDR genre and provide a more detailed description of effective EDRs, the present study draws on the ESP tradition of genre analysis and utilizes corpus-based methodologies to study professional EDRs. In analyzing professional EDRs, the goals of the study are to (a) determine conventional discourse structures and the acceptable range of structural variations and (b) identify linguistic features that are associated with particular EDR organizational units. To achieve the aims specified above, a set of research questions will be answered for each major step of the study, as listed below:

I. Research questions for the comparison of professional and student EDRs

1. What are the situational characteristics of student and professional EDRs?
2. How do the situational characteristics differ between EDRs written in professional workplace and university settings?
3. How do core lexico-grammatical features differ between student and professional EDRs?
4. How do linguistic features associated with grammatical complexity differ between student and professional EDRs?

II. Research questions for the genre analysis and the linguistic comparisons across organizational units within professional EDRs

1. What is a typical discourse structure (i.e., major organizational units) of EDRs written by practicing engineers?
2. What is a typical rhetorical move sequence for each organizational unit in professional EDRs?
3. How do core lexico-grammatical features differ across organizational units in professional EDRs?

III. Additional research questions

1. What additional insights can be gained from integrating genre-based and register-based approaches to discourse analysis?
2. What are pedagogical implications of the study results?

CHAPTER 3. THE SITUATIONAL CHARACTERISTICS OF STUDENT AND PROFESSIONAL ENGINEERING DESIGN REPORTS

3.1. Introduction

To help engineering students advance from novice to professional writing in terms of writing EDRs, the present study seeks to identify the gap between student and professional writing of EDRs by examining the linguistic features associated with EDRs written in professional and academic settings. However, to help us understand how and why linguistic features are used in EDRs and, therefore, to be useful to practitioners working with engineering students, linguistic variation between student and professional EDRs needs to be interpreted functionally. These functional analyses require a consideration of the external characteristics of the larger context in which EDRs are written (i.e., the situational characteristics of texts). Chapter 3 presents an analytical framework for analyzing the specific situational characteristics of student and professional EDRs and reports the results of a situational analysis of EDRs with the developed EDR framework. The linguistic analysis of student and professional EDRs is then discussed in Chapter 6.

3.2. Situational Analysis

Functional interpretations of linguistic variation between student and professional EDRs require not only analyses of linguistic features and situational characteristics of EDRs, but also call for principled methodologies to be used for these analyses. That is, to carry out a situational analysis, one needs a reliable way to identify situational characteristics of a particular register; these characteristics then can be examined during the situational analysis. An analytical framework of situational characteristics offers a principled way to identify and analyze relevant non-linguistic characteristics of registers. The purpose of this chapter is to (a) present an analytical framework for analyzing situational characteristics of EDRs written in professional and academic settings and (b) apply this framework to student and professional EDRs.

3.2.1 Development of the EDR Situational Analysis Framework

Conrad (1996) lists several benefits that a well-developed analytical framework of situational characteristics can offer to linguists. In particular, such a framework could help (a) identify consistent contextual characteristics of specific registers, (b) reveal shared characteristics and typical variation within these registers, and (c) determine characteristics associated with linguistic variation in these registers. To develop such an analytical framework, Conrad (1996) recommends that four conditions be met. First, the analysis of situational characteristics needs to be carried out independently from a linguistic analysis. Second, the framework needs to be as comprehensive in its coverage of possible situational characteristics as possible. Third, the framework should allow for rapid analyses and therefore be suitable for use with a large number of texts. Finally, a well-developed framework should enable a thorough understanding of variation by making possible comparisons among texts on multiple levels, including those "across text categories within each discipline (e.g., research articles vs. textbooks), across disciplines for each text category, across individual texts within a category and discipline, and across the internal sections of texts" (p. 43).

Investigating variation among professional texts and the development of student writing in the fields of biology and history, Conrad (1996) developed a framework of situational characteristics that met the abovementioned requirements. The framework consists of seven parameters that were deemed important for such an analysis based on previous research and on the results of interviews with professionals in biology and history. Conrad's framework includes the following parameters: participants, setting, physical layout, purpose, subject matter, evidence, and explicitness of knowledge-making procedures, with each parameter covering multiple characteristics.

Several parameters used in Conrad's (1996) study were discussed in previous research. For instance, in his article on representativeness in corpus design, Biber (1993) attempts to develop a framework that would allow distinctions "among the range of situational differences that have been considered in register studies" (p. 245). Describing the development of this framework, Biber also stresses the need to balance the comprehensiveness of the framework with its feasibility for work with large corpora. The framework in Biber (1993) covers such parameters as channel (i.e., spoken or written), format (i.e., published or unpublished), setting (i.e., physical context of communication, such as time and place), addressee, addressor, factuality (i.e., informational or imaginative), purposes (e.g., to persuade or inform), and topics. Table 3.1 shows situational parameters used in the Biber (1993) and Conrad (1996) frameworks (first two columns) and identifies their overlapping and unique parameters. As can be seen, two identical parameters appear in both Biber (1993) and Conrad (1996): setting and purpose(s). The slight differences that can be seen are the result of Conrad's modifications to make a subset of the parameters more appropriate for analyses of disciplinary writing. For example, Biber's *addressee* and *addressor* were combined under the label *participants* in Conrad's framework. *Topics* became *subject matter*, and *format* was renamed *physical layout*. On the other hand, such parameters in Conrad's framework as *evidence* and *knowledge-making procedures* were developed to address particular concerns in disciplinary studies.

A more recent (and more general) framework of situational characteristics developed by Biber and Conrad (2009) can be applied to any register analysis. As Table 3.1 illustrates, this framework (in the third column) includes such parameters as participants, relationships among participants, channel, production circumstances, setting, communicative purposes, and topic. Because this framework is very general, it indeed can be used to compare registers with respect to many situational characteristics. However, the general nature of the framework also demonstrates its drawbacks because some characteristics may not be relevant to some comparisons, especially if the texts that are being analyzed share most of these parameters, such as in the case of the present research on EDRs.

Another recent framework for the analysis of situational characteristic was created by Gray (2011) for the purposes of a functional interpretation of linguistic variation across published academic journal articles in several disciplines. Gray's framework was developed specifically to help distinguish among theoretical, qualitative, and quantitative research articles in such disciplines as philosophy, history, political science, applied linguistics, biology, and physics. As can be seen in Table 3.1 (the far right column), Gray's framework overlaps with those developed earlier by Biber and Conrad, but it also includes newly created characteristics, deemed especially relevant for the texts analyzed in Gray's study. Gray's framework provides additional insight in terms of a variety of situational characteristics that may be considered pertinent for studying particular genres.

However, the framework's unique situational characteristics were not deemed particularly relevant for examining EDRs.

Table 3.1 Situational parameters used in previously developed analytical frameworks

Biber (1993)	Conrad (1996)	Biber and Conrad (2009)	Gray (2011)
Overlapping Situational Parameters			
• Addressee and Addressor • Setting • Primary channel • Purposes • Topics • Format	• Participants • Setting • Purpose • Subject matter • Physical layout • Evidence	• Participants • Setting • Channel • Communicative purposes • Topic	• Participants • Setting • Textual layout • Subject/Topic • Purpose • Nature of data or evidence
Unique Situational Parameters			
• Factuality	• Explicitness of knowledge-making procedures	• Relationships among participants • Production circumstances	• Methodology • Explicitness of research

To develop a modified analytical framework suitable for comparing EDRs written in academic and professional settings (i.e., an EDR framework), the present study followed Biber and Conrad's (2009) advice about using multiple sources of information about the situational characteristics associated with a particular register. Thus, the development of the EDR framework of situational characteristics relied on the following multiple sources: (a) previous studies involving the development of a framework of situational characteristics for disciplinary writing, (b) the researcher's experience and observations, (c) the results of a pilot analysis of engineering design reports produced by students and professionals, (d) previous research on writing practices in academic and professional settings, and (e) expert informants.

Specifically, the development of the framework of situational characteristics for this study followed two steps: (a) adapting the existing situational frameworks for the purposes of this study and (b) adding situational parameters and characteristics relevant for studying EDRs. First, the frameworks developed by Biber and Conrad (2009) and Conrad (1996) were compared in terms of their relevance for analyses of EDRs (see Table 3.1). The framework presented by Biber and Conrad (2009) seems to offer an effective way to explore and compare spoken and written registers, but did little to help differentiate between two specialized written registers. The second framework, developed by Conrad in 1996, was created specifically for the purposes of comparing discipline-specific written genres in the fields of biology and history.

While Conrad's (1996) framework helps depict the range of linguistic variation in disciplinary writing in such vastly different fields as biology and history, it may not be the optimal choice for comparing registers within the same discipline, such as EDRs written by engineering students and practicing engineers. In fact, a pilot study (Poltavtchenko, 2009) carried out with two small corpora of engineering design reports clearly demonstrated a need for the development of a modified framework that would be best suited for analyses of EDRs. Therefore, it was decided to create the EDR framework of situational characteristics, using a combination of the frameworks developed by Biber and Conrad (2009) and Conrad (1996) as a base and adding and modifying certain situational parameters and their characteristics based on additional information.

The second step involved incorporating situational parameters and characteristics that might be relevant based on the prior experiences and observations of the researcher. Specifically, the researcher previously taught (a) engineering writing workshops that supported students' work in senior design courses and (b) a sophomore-level technical communications class for engineering students at a large urban university in the U.S.

These teaching experiences and related observations—gained through close collaboration with engineering faculty teaching capstone classes and with engineering students—helped further inform the decisions that went into designing the new framework. As a result, the following characteristics were added to the framework: the level of training in the discipline (for the Participants parameter), expected amount of shared disciplinary knowledge (for the Relationships among Author(s) and Reader(s) parameter), and degree of planning and degree of revision (for the Writing Process parameter).

Biber and Conrad (2009), however, caution that "observers or novices in a professional domain generally cannot fully describe the registers identified by practitioners in that domain" (p. 38). Thus, additional sources of information were consulted in the process of developing the EDR framework specific to this study. These sources included (a) previous research on writing in academic and professional settings and (b) interviews with both practicing engineers who write design reports and engineering faculty who assign them to their upper-division university students.

Based on previous research investigating writing practices in academic and professional settings, and most importantly, the transition of college graduates into various fields of study into the workplace (Dias & Paré, 2000; Freeman & Adam, 2000; Spilka, 1993; Young & Fulwiler, 1986), several characteristics were added to the developing EDR framework of situational characteristics. For example, such characteristics as seniority within organization or group, the collaborative nature of writing practices, and the pre-submission audience (or guides) were added to the Participants parameter. Following Freedman and Adam (2000), the last characteristic labeled *guides* includes (a) colleagues and mentors in the workplace, (b) classmates and instructors in the classroom, and (c) other resources, such as textbooks, handouts, and models, in both contexts. In addition, relation to author's learning needs was added to the Setting parameter; and the time and results of guidance provided by the guides were included with the Writing Process parameter of the modified framework.

Further, semi-structured interview questions and an online survey were developed for practicing engineers and engineering faculty members to test the differentiating power of the developed EDR framework of situational characteristics (Poltavtchenko, 2010a). Specifically, two survey-based research instruments were developed for the study: a set of 23 questions for a semi-structured in-person interview and a 44-item online survey. The interview questions aimed to help answer questions about (a) the purposes for writing design reports in the workplace and in engineering courses, (b) the frequency of writing these reports by practicing engineers and engineering students, and (c) the evaluation criteria used to assess the quality of design reports in professional and academic settings (see Appendices A–F for copies of the interview questions and online survey). The online survey, created by using the Qualtrics Online Survey tool (available at www.qualtrics.com), focused on the situational characteristics used to differentiate between contexts of EDRs written by professional engineers and those written by engineering students. In this small-scale study that used the EDR framework of situational characteristics, 12 practicing engineers working in a large American technology and services conglomerate and 4 engineering faculty members from a public university in the US were first interviewed in person and then asked to complete the online survey. All participants in both settings (for a total of 16 participants) completed both tasks.

It must be noted that at the time of this study, EDRs were not yet identified as a target genre of this research. Hence, though the purpose of interview and survey questions was to ask respondents about the EDR genre, the questions were phrased to inquire about engineering technical reports (ETR), an overarching genre. Nevertheless, because study participants were provided with a working definition of an EDR (called ETR in the study); their responses can be considered suitable for the analysis of situational characteristics of EDRs. The results of online surveys are presented in Sections 3.2.3.1–3.2.3.7. The results of the interviews are discussed in Section 3.2.3.8.

The analysis of semi-structured interview data showed that EDRs are, in fact, a genre recognized by professionals and faculty alike. However, purposes, frequency, and evaluation criteria for design reports differ in a number of ways in the two settings. The results of online surveys completed by participants in both settings revealed that most situational characteristics in the analytical framework piloted in the study helped differentiate between EDRs written in the workplace and in academia.

3.2.2 EDR Framework of Situational Characteristics

The resulting framework of situational characteristics (Table 3.2) developed for the study consists of eight general parameters: Participants, relationships among author(s) and reader(s), setting, writing process, physical layout, explanation of the evidence, explanation of the procedures, and communicative purpose(s). These parameters are then broken down into specific situational characteristics (see the right column), which will be presented and discussed in Sections 3.2.3.1–3.2.3.8, one subsection for each parameter. The full EDR framework of the situational characteristics (i.e., the framework containing all possible response choices for each characteristic) is presented in Appendix G.

Table 3.2 Framework for describing the situational characteristics of EDRs

Parameter	Characteristic
1. Participants	A. Author(s) B. Audience C. Guides
2. Relationship between / among author(s) and audience	A. Power differential B. Expected amount of shared disciplinary knowledge
3. Setting	A. Request B. Relation to author's learning needs C. Place of communication D. Method of communication
4. Writing process	A. Degree of planning B. Degree of revision: C. Time of guidance D. Results of guidance
5. Physical layout	A. Length B. Organization C. Reference style used, if any
6. Explanation of evidence	A. Explanation of primary evidence B. Explanation of secondary evidence
7. Explanation of procedures	A. Explanation of procedures
8. Communicative purpose(s)	A. Overall purpose for writing report

3.2.3 Analysis of Situational Characteristics of Student and Professional EDRs

This section discusses the situational analysis of student and professional EDRs based on close examination of the EDR corpora and the use of the EDR situational framework developed for the study. Sections 3.2.3.1–3.2.3.8 highlight differences and similarities in situational characteristics of student and professional EDRs for each of the eight situational parameters of the EDR framework. Each of these sections also includes a table with study participants' responses to the online survey and interview questions. These responses are shown in bold and are sequenced from the most frequent to most infrequent. Particular responses are then further explained in the text of the accompanying section. For each discussed characteristic, only responses provided by the study participants were included in the sections' tables. For all possible response choices, please see the full situational framework in Appendix G.

Note that some survey questions asked study participants about other EDR writers' behavior; therefore, responses received to such questions, though truthful, are based on speculation. For instance, when analyzing the Writing Process parameter, engineering faculty were asked about their students' writing practices in terms of planning, drafting, and revising EDRs. Further, practicing engineers were sometimes asked about their own practices in writing EDRs, but their answers were then extrapolated to practices of engineers who wrote EDRs analyzed in this study.

3.2.3.1. Parameter 1: Participants

The analysis of the Participants parameter involved investigation of author(s), their audience, and other people or resources (i.e., guides) consulted in the process of planning, writing, or revising design reports (as shown in Table 3.3). When analyzing the author(s), the following factors were deemed to have merit for further analysis: number of authors, their level of training in the discipline, and their seniority within an organization or school. In terms of the audience, three factors were considered in the present analysis: number of readers, distribution within or outside an organization or classroom, and audience's training in the discipline. Finally, the guides characteristic consists of (a) the pre-submission audience's primary role as either evaluators or collaborators, (b) their focus on either writer's learning or success of communication, and (c) accessibility of various resources assisting students and professionals in writing EDRs. Part 1 of Appendix B lists specific survey questions asked of the participants in professional settings while Part 1 of Appendix E includes questions asked of the engineering faculty.

As Table 3.3 shows, it appears that when practicing engineers write design reports for grant-issuing agencies, they write as a specific group of individuals, but they represent the whole organization. On the other hand, even though many capstone design courses require student groups to create fictitious company names in an attempt to simulate real-life engineering projects, students typically do not perceive themselves as part of a real company.

Further, the level of training in engineering is very different in the two contexts being considered here, professional engineers versus upper-division students (the latter engineers in the early stages of professional training). It could also be assumed that the level of seniority between these two types of writers will also be different. It is highly likely that an organization would ask the most competent, and probably senior engineers, to report on a governmentally supported project. On the other hand, according to engineering faculty, it is possible to encounter engineering juniors, and even few lower-division university students, enrolled in senior capstone design courses.

Table 3.3 Parameter 1: Participants in professional and academic settings

Professional EDRs	Student EDRs
I. PARTICIPANTS	I. PARTICIPANTS
A. Author(s)	A. Author(s)
1. Number of authors **Organization / group**	1. Number of authors **Group / organization (fictitious)**
2. Level of training in the discipline: **Professional**	2. Level of training in the discipline: **Upper-division student**
3. Seniority within an organization: **Varies**	3. Seniority within a school: **More than 2 years**
B. Audience	B. Audience
1. Number of readers **Client(s) / organization / unidentified**	1. Number of readers **Faculty/ client(s) / unidentified**
2. Distribution **Those outside of an organization**	2. Distribution **Those within an organization (or class)**
3. Level of training in the discipline: **Professional**	3. Level of training in the discipline: **Professional (engineering professor)**
C. Guides (i.e., colleagues, mentors, instructors, and other resources)	C. Guides (i.e., colleagues, mentors, instructors, and other resources)
1. **Primarily collaborators**	1. **Primarily evaluators**
2. **Focus on the written product and success of communication**	2. **Focus on learning**
3. **Access to models of EDRs**	3. **Access to models of EDRs**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

The context of professional and student EDRs was also different in terms of the audience(s) for whom these reports were written. Although engineering professors surveyed during the study pointed out that in their classes students work on real-life engineering design projects (i.e., they work for real clients), these faculty members also indicated that the primary audience for student EDRs was students' professors (not their clients). Conversely, the primary audience for professional EDRs is sponsoring agencies (i.e., governmental organizations that sponsored the projects). Though practicing engineers might ask their colleagues or managers within their organization to read and provide feedback on their EDRs, these individuals are certainly not the ones for whom the reports were written.

Finally, based on the results of the pilot study and personal experiences of the researcher, it appears that writers in both professional and academic contexts typically have access to materials about EDR formats. Often professional and student writers also have access to models of full EDRs. These model EDRs are sometimes provided as part of instructions on reporting to grant-issuing agencies for engineers in the workplace. In academic contexts, example reports written by either students or professionals are frequently provided to students by engineering professors.

3.2.3.2. Parameter 2: Relationships among Authors and Readers

Following Biber and Conrad (2009), Parameter 2 of the EDR framework includes such characteristics as power differential and expected amount of shared disciplinary knowledge. Table 3.4 indicates differences and similarities in relationships among author(s) and EDR audiences in the workplace and engineering classes. As can be seen, the power differential differs in these two contexts. Although professional engineers write EDRs for readers at grant-issuing agencies and, therefore, it may seem that these authors' power status is lower than that of their audience, in reality these professionals report on work already completed and paid for, thus making it likely that they would see their readers as equals. In academic settings, a different power dynamic can be observed; students, while communicating with real-life clients, primarily write for their engineering professors to fulfill course requirements, creating a low-to-high power differential.

Table 3.4 Parameter 2: Relationships among authors and readers in professional and academic settings

Professional EDRs	Student EDRs
II. RELATIONSHIPS	II. RELATIONSHIPS
A. Power differential	A. Power differential
1. **Equal**	1. **Low -> High**
B. Expected amount of shared disciplinary knowledge	B. Expected amount of shared disciplinary knowledge
1. **Medium**	1. **Medium**
2. **High**	2. **Low**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

Further, responses to the study's survey questions about relationships between author(s) and audience show that, in both settings, the authors often engage in writing about very narrow engineering topics about which audiences may have little disciplinary knowledge. Thus, the amount of expected shared disciplinary knowledge among the participants in both settings seems to be medium. Although in the workplace the expectations of shared knowledge are somewhat higher, it is possible that some audiences may be familiar with all fundamental concepts of engineering but may not know a lot about a particular very narrow area of engineering to which a particular project belongs. In engineering classrooms, while the primary audience (i.e., the professor) typically possesses a high amount of shared knowledge about student projects, the real-life client organization may involve audiences consisting of managers who may not be familiar with the technical concepts discussed. In addition, professors frequently ask students to describe their projects as if students are writing to an audience with some technical knowledge, but not necessarily specific to the technical concepts they are discussing.

3.2.3.3. Parameter 3: Setting

In previous frameworks, the Setting parameter has referred to a place (Biber, 1993) or physical setting of the text (Conrad, 1996). Biber (1993) differentiates among three separate characteristics comprising this parameter: institutional discourse, other public discourse, and private personal discourse. While these characteristics would work well to help find similarities and differences among the types of discourse produced in these different target settings, these characteristics would not help differentiate between EDRs written by a company's engineers or university upper-division engineering students. Further, Conrad (1996) used the setting parameter to focus on the actual physical setting of the text, such as a country where a professional paper was published. Because the present study examines situational characteristics of design reports that were not published, and were all written in the US, such a view of the setting parameter would not have helped advance this study. Finally, Gray's (2011) framework defined setting parameter as one concerned with the status of the journal in which texts in her corpus were published, thus differentiating between 'specialized' and 'generalist' journals. Again, such an understanding of the setting parameter would not have allowed pinpointing contextual differences between professional and student EDRs, all of which can be considered specialized texts. Therefore, a different approach to understanding what is involved in the text's setting was taken. Part 3 of Appendix B shows specific questions asked of the participants in professional settings while Part 3 of Appendix E lists questions asked of the engineering faculty.

As Table 3.5 shows, the Setting parameter used in this study comprises the following characteristics: distribution of EDRs (i.e., at whose request EDRs were written), relation to author's learning needs, place of communication, and method of communication. As can be seen, practicing engineers working on EDRs for grant-issuing organizations write these reports primarily to be used outside their company, though these documents could also sometimes be used for internal purposes. On the other hand, in upper-division university classes, engineering students typically write EDRs to both satisfy their course requirements and to complete real-life projects.

Table 3.5 Parameter 3: Setting in the workplace and upper-division university classes

Professional EDRs	Student EDRs
III. SETTING	III. SETTING
A. Request	A. Request
1. **By an organization for external use**	1. **By a faculty member teaching upper-division engineering classes**
B. Relation to author's learning needs	B. Relation to author's learning needs
1. **Unrelated** (i.e., tasks are focused on material or discursive outcomes and participants are often not focused on the learning that occurs)	1. **Related** (i.e., writing tasks are carefully sequenced and designed, they are simplified and facilitated)
C. Place of communication	C. Place of communication
1. **Workplace**	1. **University class**
D. Method of communication	D. Method of communication
1. **Electronically**	1. **Electronically**
	2. **In person**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

In terms of the relation of writing EDR to author's learning needs, it became clear from the answers to the study's interview questions that engineering professors assign EDRs to their students in order to achieve several purposes, many of which are pedagogical in nature. In the workplace, this tendency has not been observed, as practicing engineers focus on the outcomes of their writing more than on the process of writing and learning from these writing experiences.

Finally, in terms of the place and method of communication associated with writing EDRs in the two settings, there were differences in terms of place but some similarities in terms of method. As can be seen in Table 3.5, the place of communication was the workplace in the professional setting and university in the academic setting. However, as the study's responses demonstrate, in both settings, respondents prefer to communicate about their design reports mostly electronically. This seems to be especially true of the workplace environment, in which writers simply do not have a luxury of in-person communication with grant-issuing agencies. In the academic setting, two engineering faculty indicated that they communicate with their students about EDRs in person, as the primary method of communication; two other professors said they communicate with their students mostly electronically.

3.2.3.4. Parameter 4: Writing Process

Because the linguistic analyses of EDRs involve two written registers, it was decided that writing processes involved in the development of EDRs may influence the use of linguistic features by EDR writers in the two settings. Therefore, the EDR framework contains the situational parameter entitled *writing process* that examines such characteristics as the degree of planning, degree of revision, time of guidance by the guides of the author(s), and the results of this guidance. Part 4 of Appendix B shows specific questions asked in professional settings, while Part 4 of Appendix E provides questions asked in academic settings.

Table 3.6 shows the most frequent responses to survey questions about these characteristics in academic and professional settings. According to the practicing engineers interviewed in the study, most engineers in the workplace spend about one to five hours on planning the writing of their EDRs. After this planning stage is complete, these engineers typically spend one to five additional hours actually writing their reports. Interestingly, most practicing engineers produce approximately three-four drafts of their EDRs and spend an additional one to five hours revising their reports. Because practicing engineers who participated in the study primarily produced EDRs for company's internal uses, it is entirely conceivable that professional engineers writing EDRs for grant-issuing agencies spend even more time on all stages of the writing process.

Table 3.6 Parameter 4: Writing process in professional and academic settings

Professional EDRs	Student EDRs
IV. WRITING PROCESS	IV. WRITING PROCESS
A. Degree of planning	A. Degree of planning
1. **Moderate**	1. **Minimal**
B. Degree of revision	B. Degree of revision
1. **Extensive**	1. **Moderate**
C. Time of guidance	C. Time of guidance
1. **Before EDR is completed**	1. **Before EDR is completed**
2. **After EDR is completed**	2. **After EDR is completed**
D. Results of guidance	D. Results of guidance
1. **Collaborative effort in revision stages**	1. **Collaborative effort in revision stages**
2. **Individual revisions**	2. **Individual revisions**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

The majority of workplace respondents indicated that they revise EDRs based on the feedback that they receive from other engineers in their company, immediate supervisors, and other company managers. When asked about the nature of the feedback that they typically receive from these readers, practicing engineers named content, amount of detail, and clarity of writing as the most frequent suggestions for revision.

In academic settings, according to the engineering professors who participated in the study, although more time is generally given to students to write EDRs, students typically spend less time on planning their writing when compared to practicing engineers. In particular, all engineering faculty indicated that they typically give half of the semester (approximately 7 weeks) to their students for writing EDRs. Yet, half of the faculty members stated that their students spend less than an hour planning the writing of these reports, and another half of the faculty respondents reported that the students spend one to five hours on planning. When asked whether their students are typically asked to produce more than one draft of their reports, most faculty stated that their students write one-two drafts before turning in their EDRs.

These engineering professors also stated that it takes their students about one to five additional hours to revise their design reports, which students do collaboratively. To account for everyone's participation in the project, including writing EDRs, engineering faculty reported using peer evaluation forms at the end of the semester. The feedback that students receive on the EDRs primarily comes from their professor in the form of either grading rubrics or comments on students' drafts. Similar to the professional setting, after the students submit their EDRs, rarely do they have an opportunity to substantially revise or rewrite them.

3.2.3.5. Parameter 5: Physical Layout

The fifth parameter of the developed EDR framework, Physical Layout, covers the internal layout of the texts, their overall length, and reference style(s) used by the engineering discourse community members in the two settings. Part 5 of Appendix B shows specific questions asked of participants in professional settings, while Part 5 of Appendix E lists questions asked of the engineering faculty.

Table 3.7 shows the most frequent responses by the participants in both settings to the study's survey questions about physical-layout characteristics. According to the study workplace respondents, reports written in professional settings are rather short and often range from one to ten pages in length. In fact, several study participants stressed that the EDRs that they write were often "shorter than ten pages." The average length of a professional EDR collected for the present study was 17.9 pages, ranging from an average of 12.7 pages for an EDR from the NASA database to an average of 33 pages for an EDR from the ERDC database.

According to the study participants in two settings, when writing EDRs, practicing engineers seem to follow the same sequence of sections as engineering students, and both the sections and the sequence are important to adhere to according to most professional-setting respondents. Most respondents stated that there is no specific reference style that they use for their EDRs, yet four respondents named IEEE (Institute of Electrical and Electronics Engineers Standards style manual) as the reference style that they use. The analysis of professional EDRs collected for the present study confirmed professional engineers' responses in the study, showing that while EDRs adhere to some reference style, there is not a specific reference style that most reports follow. This finding can be explained by an abundance of reference styles available to members of different discourse communities associated with various engineering disciplines and a lack of specific guidelines from client organizations requesting EDRs.

In the academic setting, EDRs written by students in upper-division engineering classes are typically longer than those written by practicing engineers. Thus, two faculty members indicated that students in their classes write on average approximately 11 to 20 pages. Another engineering professor stated that his students typically write 21 to 30 pages. Finally, the fourth faculty member said that, in his classes, students generally write EDRs that are around 40 pages long. The analysis of student EDRs collected for the study showed that student EDRs indeed were slightly longer than professional EDRs, averaging 25.2 pages in length. Differences in EDR length seem to correspond to differences in engineering disciplines and, more importantly, to specific requirements of engineering faculty members. Thus, while the average length of EDRs collected from one university was only 11.5 pages, the average length of EDRs from another university was much higher (32.2 pages). For the purposes of this study, the length of an EDR includes only pages of the body of the report, excluding front (i.e., abstracts, executive summaries, title pages, and table of contents) and back matter (i.e., references and appendices).

Table 3.7 Parameter 5: Physical layout in professional and academic settings

Professional EDRs	Student EDRs
V. PHYSICAL LAYOUT	V. PHYSICAL LAYOUT
A. Length (in pages)	A. Length (in pages)
1. **Average: 18**	1. **Average: 25**
2. **Range: 4–49**	2. **Range: 6–50**
3. **Standard deviation: 10.3**	3. **Standard deviation: 12.2**
B. Organization	B. Organization
1. **Introduction, Method, Results, Discussion, Conclusion**	1. **Introduction, Method, Results, Discussion, Conclusion**
C. Reference style used, if any	C. Reference style used, if any
1. **No particular style**	1. **No particular style**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

In terms of general layout, according to pilot study's respondents, a typical report written by students in upper-division engineering classes seems to follow an organizational pattern that is similar to professional reports. Specifically, although engineering professors may have used slightly different terms to refer to various EDR sections, these sections seem to follow the sequence described by professional engineers to fulfill similar communicative purposes within a design report. In addition to the sections mentioned by practicing engineers, engineering professors require students to include a title page, table of contents, references, and appendices. The completeness of the reports is extremely important to engineering faculty, while following the exact sequence is important but not absolutely required. Similar to the professional setting, all but one engineering faculty had no required reference style for EDRs.

3.2.3.6. Parameter 6: Explanation of Evidence

Following Conrad's (1996) framework developed for analysis of professional and academic writing, this study included situational parameters focusing on the explanation of evidence (Parameter 6) and explanation of procedures (Parameter 7). Notably, Parameter 6 in the present study does not concern itself with such distinctions as the nature of evidence (i.e., reliance on primary vs. secondary evidence) or the type of evidence (i.e., quantitative vs. qualitative), just the extent to which the evidence, both primary and secondary, is described. Part 6 of Appendix B provides specific questions asked in professional settings, while Part 6 of Appendix E shows questions asked in academic settings.

Table 3.8 illustrates the major differences found in this parameter in EDRs written in the workplace and academia. Specifically, the Explanation of the Evidence parameter includes information about how writers of EDRs explain their primary and secondary evidence. According to practicing engineers who participated in the study, these writers have a rather good understanding of what their audiences expect of them. Thus, they provide moderate to extensive evidence of their primary evidence, thereby matching their readers' expectations. In terms of their explanation of secondary evidence, or work done by the others, practicing engineers seem to provide even more explanation than is expected of them.

In the academic setting, however, the opposite pattern is observed. As attested by engineering faculty respondents, engineering students tend to provide only a limited explanation for both primary and secondary evidence whereas their audiences expect at least a moderate explanation of the evidence used by students.

Table 3.8 Parameter 6: Explanation of evidence in professional and academic settings

Professional EDRs	Student EDRs
VI. EXPLANATION OF EVIDENCE	VI. EXPLANATION OF EVIDENCE
A. Explanation of primary evidence	A. Explanation of primary evidence
1. **Extensive**	1. **Limited**
2. **Moderate**	
B. Explanation of secondary evidence	B. Explanation of secondary evidence
1. **Extensive**	1. **Limited**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

3.2.3.7. Parameter 7: Explanation of Procedures

Survey results reveal that the Explanation of Procedures parameter showed patterns somewhat similar to those discussed in Section 3.2.3.6 on explanation of evidence. Part 7 of Appendix B lists specific questions asked of the participants in professional settings, while Part 7 of Appendix E shows questions asked of engineering faculty. As can be seen in Table 3.9, practicing engineers stated that they generally have a good sense of their audience's expectations in terms of explanation of procedures. The EDR writers in the workplace maintained that they typically provide extensive to moderate explanation of procedures. At the same time, according to their professors, engineering students tend to provide slightly less information than their professors expect. Specifically, while students provide limited to moderate explanation of the procedures involved in their design projects, the faculty expect these writers to provide moderate to extensive explanation.

Table 3.9 Parameter 7: Explanation of procedures in professional and academic settings

Professional EDRs	Student EDRs
VII. EXPLANATION OF PROCEDURES	VII. EXPLANATION OF PROCEDURES
A. Explanation of procedures	A. Explanation of procedures
1. **Extensive**	1. **Moderate**
2. **Moderate**	2. **Limited**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

In addition, it is interesting to note that practicing engineers feel that their audiences do not expect them to explain such procedural details as test procedures, common or known formulas and equations, instrument checks, and calibration procedures. In contrast, engineering faculty did not feel that anything should be omitted by their students in the explanation of procedures.

3.2.3.8. Parameter 8: Communicative Purpose(s)

The last parameter of the framework developed and tested in this study follows previously developed frameworks (Biber & Conrad, 2009; Conrad, 1996; Gray, 2011) and includes overall communicative purpose. In the study, the overall communicative purpose for writing EDRs was covered in six of the interview questions for practicing engineers and engineering faculty (see Part QT1 in Appendices A and D for specific questions).

The analysis of data from interviews with practicing engineers and engineering faculty showed that in the two settings EDRs are written or assigned for a variety of purposes and that the purposes for writing or assigning design reports in the two settings were rather different. Table 3.10 illustrates the major differences in communicative purposes in EDRs written in the workplace and in academia. While the answers of practicing engineers reflected their overall goal of advancing their team's and organization's activities, the purposes discussed by the engineering faculty members were geared toward the pedagogical objectives of their courses and student benefits.

Table 3.10 Parameter 8: Communicative purpose(s) in professional and academic settings

Professional EDRs	Student EDRs
VIII. COMMUNICATIVE PURPOSE A. Overall purpose for writing report 1. **Present design that addresses specific need(s)** 2. **Demonstrate general understanding of the field** 3. **Show understanding of project** 4. **Share knowledge with colleagues** 5. **Demonstrate deep knowledge of a narrow subfield** 6. **Advance knowledge of company's engineers and make company more efficient** 7. **Keep records** 8. **Distribute innovative technical information early in the information flow process**	VIII. COMMUNICATIVE PURPOSE A. Overall purpose for writing report 1. **Present design that addresses specific need(s)** 2. **Demonstrate general understanding of the field** 3. **Display information known in field** 4. **Demonstrate knowledge of one's project** 5. **Demonstrate ability to analyze data and write EDRs**

Note: For each situational characteristic, the responses of pilot study respondents in professional and academic settings are presented in bold. These responses are sequenced so that the most frequent is presented first while the most infrequent is last. For each characteristic, only responses provided by the study participants are included. For all possible response choices, please see the full situational framework in Appendix G.

Specifically, most respondents in the workplace named such purposes for writing EDRs as meeting FDA requirements, showing one's understanding of the project and sharing this knowledge with one's colleagues, and keeping records. As can be seen, achieving these purposes facilitates design work of one's engineering team by advancing the team members' understanding of all aspects of the design. In addition, meeting FDA requirements also shows that the company follows governmental regulations. Finally, keeping records for other engineers in the company enables all company engineers to have access to records of previously completed work, which they can use as starting points for their own projects. Overall then, these purposes help advance knowledge of all engineers and make the company more efficient as a whole. Two of the purposes named by the practicing engineers in this study, namely sharing knowledge and keeping records, were also mentioned in several technical writing textbooks (Beer & McMurrey, 1997; Finkelstein, 2005; Paradis & Zimmerman, 1997). However, depending on the field in which a particular engineering company operates, additional purposes may arise, such as meeting requirements of various governmental agencies (e.g., the FDA for engineers working in the healthcare sector).

In the context of EDRs written for governmental sponsoring agencies, these additional communicative purposes can be to satisfy contractual requirements and to distribute crucial innovative information early in the information flow process. In fact, as early as the 1980's, McClure (1988) noted that a discerning attribute of technical reports, an overarching genre to which EDRs collected for the professional corpus of this study belong, is that "these types of publications are especially important because they are distributed early in the information flow process. They contain more material than their subsequent journal counterpart because they have fewer limitations on length, format, style, appendices, and speculation/rhetoric" (p. 28).

In the academic setting, the main purposes for assigning EDRs in upper-division classes differed from those named in the workplace. It was expected that the main purposes for assigning design reports to students would be geared more toward pedagogical objectives set out by individual professors. Therefore, it was not surprising that the results of the analysis showed a somewhat uniform picture in terms of the most important purposes for having students write EDRs. In particular, the engineering faculty named such purposes as (a) analyzing and working with data and (b) demonstrating one's understanding of one's project as important for students' success in their classes. These purposes are expected of any academic program, where a general understanding of course subject matter at hand is required for an evaluation of individual students' progress. However, the main purpose for assigning EDRs indicated by all engineering professors was somewhat unexpected. Specifically, all faculty members stated that they assign EDRs to provide students with an opportunity to write, and to write design reports in particular. These purposes seem to corroborate Storch and Tapper's (2000) statement that

> Although [assignments in university classes] are primarily a means of assessment, they may also be regarded as a way to help students to explore and to learn content, as a means of preparing students to become professionals in that discipline, and as a means of teaching academic and discipline-specific writing. (p. 337)

The results of the analysis, however, highlight the particular emphasis engineering faculty placed on communication about one's work on a real-life design project. This emphasis seems to reflect the general ABET criteria for advanced-level programs stating that engineering programs must include "an engineering project or research activity resulting in a report that demonstrates both mastery of the subject matter and a high level of communication skills" (ABET, 2007, p. 4). Because even for baccalaureate engineering programs ABET (2013) stresses both (a) the ability to design an artifact that meets desired needs and (b) the importance effective communication skills, it is not surprising that engineering faculty seek to provide students with opportunities to practice these skills. The analysis results, however, also suggest that engineering professors feel their students do not have many chances to write in their engineering programs, and write enough EDRs to prepare them for the workplace.

3.3. Summary

The situational analysis presented in Section 3.2.3 has shown variation between professional and academic settings in terms of the external characteristics of EDRs. While these differences have been summarized in Tables 3.3–3.10 above and discussed in corresponding sections, this section will highlight the most surprising results of this situational analysis. Table 3.11 provides a summary of major findings of the analysis, specifically listing all found similarities and differences in situational characteristics of EDRs written in professional and academic settings.

As the table reveals, although both registers examined in this analysis were EDRs, only a few situational characteristics were found to be similar in the two settings. These characteristics include (a) level of training of EDR audience and accessibility of EDR models in the Participants parameter, (b) time and results of guidance in the Writing Process parameter, and (c) organization and reference style used in the Physical Layout parameter. It appears that both practicing engineers and engineering students are writing EDRs for professional engineering audiences. Further, EDR writers in professional and academic settings typically have access to models of EDRs and receive guidance on their writing before and after EDRs are drafted. As a result of this guidance, EDR writers engage in revisions both collaboratively and individually, depending on the demands of a particular project. Finally, according to the study participants, EDRs written in the workplace and in university courses follow the same sequence (i.e., Introduction, Method, Results, Discussion, Conclusion). In addition, in both settings, those EDRs that include references or a bibliography relatively consistently follow a reference style; however, the study did not find any specific reference style used consistently within a setting, an engineering discipline, or engineering course. Finally, EDRs produced in both settings share some general communicative purposes of demonstrating general understanding of the field and presenting design that addresses specific need(s).

Other characteristics analyzed in the study show variation between the two settings, with the exception of partial overlap in the method of communication in the Setting parameter and overall purpose for writing EDR in the Communication Purpose parameter. The most prominent differences noticed between the two settings were related to pedagogical objectives for assigning EDRs in engineering courses and the lack of such objectives in the workplace. In particular, the guides in academic settings serve primarily as evaluators, with their focus on writers' learning, whereas in the workplace this pre-submission audience primarily plays a role of collaborators, with their focus on writer's successful communication. These differences appear to stem from to the differences identified in the Setting parameter, specifically the place of communication (workplace vs. university class) and relation to author's learning needs (unrelated in the workplace vs. related in academia).

Table 3.11 Summary of the results of the situational analysis

Characteristic	Similarities	Differences
Author	group/organization	professional versus student writers
Audience	variable level of seniority	**Professional**: client (outside an organization) **Student**: faculty and client (within and outside an organization)
Guides	access to models of EDRs	**Professional**: collaborators. Focus on written product **Student**: evaluators. Focus on learning
Power differential		**Professional**: equal **Student**: low -> high
Expected amount of shared knowledge		**Professional**: medium-high **Student**: medium-low
Request		**Professional**: by an organization for external use **Student**: By a faculty teaching a class
Relation to author's learning needs		**Professional**: unrelated **Student**: related
Place of communication		**Professional**: workplace **Student**: university class
Method of communication	electronically	**Student**: and in person
Degree of planning		**Professional**: moderate (1-4 hours) **Student**: minimal (1 hour or less)
Degree of revision		**Professional**: extensive (3-4 drafts, 1-5 hours, seek feedback from colleagues and supervisors) **Student**: moderately (1-2 drafts, 1-5 hours)
Time of guidance	before and after EDR is completed	
Results of guidance	collaborative and individual revisions	
Length		**Professional**: average of 17 pages **Student**: average of 25 pages
Organization	IMRDC	
Reference style	no particular style	
Explanation of primary evidence		**Professional**: moderate to extensive **Student**: limited
Explanation of secondary evidence		**Professional**: extensive **Student**: limited
Explanation of procedures		**Professional**: moderate to extensive **Student**: limited to moderate
Overall purpose(s) for writing	demonstrate general understanding of the field, present design that addresses specific need(s)	**Professional**: keep records, show understanding of project, share knowledge with colleagues, demonstrate deep knowledge of a narrow subfield, advance knowledge of company's engineers and make company more efficient, distribute innovative technical information early in the information flow process **Student**: display information known in the field, demonstrate knowledge of one's project, demonstrate ability to analyze data and write EDRs

Interestingly, despite the lack of focus on one's learning in the workplace, practicing engineers spend more time planning, drafting, and revising their reports, writing more drafts on average and producing more concise writing containing extensive explanations of evidence and procedures. Conversely, engineering students engage in planning, writing, and revising for shorter periods of time, produce fewer drafts, and on average write longer reports, though student EDR length largely depends on instructions by particular engineering faculty. According to their professors, engineering students also provide limited-to moderate amount of explanations of evidence and procedures, showing that student writers have not yet developed a good sense of their audience's needs.

The lack of extensive explanations in student EDRs can be explained by the communicative purpose(s) of student reports. As identified by study participants, student EDRs are expected to display information known in the field, show knowledge of one's project, and demonstrate ability to analyze data and write EDRs. It is possible then that students may not perceive that this already known, general information needs to be explained. Professional EDRs, on the other hand, primarily are used to keep records, show understanding of project, share knowledge with colleagues, demonstrate deep knowledge of a narrow subfield, advance knowledge of company's engineers and make company more efficient, and distribute innovative technical information early in the information flow process. Naturally, these tasks lead practicing engineers to writing longer, more extensive explanations, with appropriate level of detail for record keeping as well as for sharing with colleagues and engineering community at large.

CHAPTER 4. BUILDING A CORPUS OF ENGINEERING DESIGN REPORTS

4.1. Introduction

The goals of the present dissertation research are (a) to conduct a corpus-based register comparison between student and professional EDRs and (b) to provide a more detailed description of professional EDRs by determining their typical rhetorical organization and identifying linguistic features associated with this this organization. To undertake these analyses, the study relies on two corpora of engineering design reports (EDRs): one with EDRs written by professional engineers and the other one with EDRs produced by students in upper-division engineering courses. This chapter first describes overall corpus design and then details separately full-text corpus compilation procedures.

4.2. Overall Design of the Full-Text Corpora of EDRs

The corpus-based methodology used in the present study allows for an empirical investigation of linguistic aspects of EDRs through computerized analyses of large, systematic and representative collections of texts (i.e., corpora). Because no previously developed corpus of EDRs was available for this study, two corpora were created to represent professionally written and typical student EDRs. The corpus comprising EDRs written by practicing engineers includes EDRs collected from five publicly available online databases. These reports document work on government-supported research and development efforts in a variety of engineering disciplines. The second corpus consists of EDRs produced by senior-level engineering students enrolled in senior design (also called capstone) engineering classes at four universities in the U.S.

To ensure representativeness (in terms of balance and sampling procedures) and prevent the corpora from being skewed by design (Biber, 1993; Biber, Conrad, &

Reppen, 1998; Biber & Jones, 2008; Conrad & Levelle, 2008; Hunston, 2008; McEnery & Wilson, 2001; Meyer, 2004), texts were selected for both corpora based on external and/or situational criteria. Selecting texts based on these criteria prevents a corpus from being skewed by design because if one bases text selection on internal, or linguistic features, the distribution of linguistic features is predetermined, and analyzing such a corpus for the purposes of discovering naturally occurring linguistic feature distributions becomes meaningless.

Specifically, to establish situational representativeness, it is crucial, especially for a specialized corpus, to ensure that text samples are collected from a range of fairly typical situations (see Biber, 1993; Koester, 2010). Thus, the full range of variability found within the genre (i.e., different sub-genres, different sources, different authors) needs to be included in the corpus. To ensure that the domain of use is represented by the two EDR corpora, texts were collected from multiple sources (five publicly available technical report databases and four universities with different types of engineering programs). These reports were written in different years, ranging from 2000 to 2010, and represent work of multiple professionals and students specializing in a variety of engineering disciplines, including electrical, computer, mechanical, industrial, civil, environmental, and bioengineering. While the study strived to ensure representativeness of both EDR corpora, it soon became apparent that collecting professional EDRs representing all typical situations, for example, EDRs written within private engineering companies, was not feasible. Therefore, it must be acknowledged that the professional EDR corpus may not represent the full population of professional EDRs, and the domain of use represented by the professional EDR corpus in this study is limited to governmentally sponsored research and development efforts.

Further, corpus representativeness also depends to a great extent on the way in which texts are selected (i.e., sampling procedures). The texts for the study were selected by using stratified sampling procedures to ensure that both corpora were balanced, with EDRs from both professional and academic settings relatively evenly represented (Biber, 1993; Hunston, 2008; Meyer, 2004). Sources of professional and student texts were identified first, and samples were then drawn from each source.

Another major consideration in corpus design was to determine its unit of analysis. Because this study sought to describe the differences between EDRs written in professional and academic contexts, a Type B corpus research design (following Biber & Jones, 2008) was used. This type of research design allows for the determination of the rate of occurrence of linguistic features in each individual text, thus making it possible to compute descriptive statistics and use inferential statistics. After the unit of analysis, overall design, and external criteria were established; further corpus design considerations centered on the length of the texts. Because the corpora described here were collected to determine the rhetorical organization of the whole text, full texts were selected for inclusion in the corpora.

The two corpora initially compiled for the study consisted of 324 engineering design reports: 98 professional reports and 226 student reports. Importantly, the quality of writing in the two corpora was not assessed. Although the quality of professional EDRs can be uneven because these publications are not peer reviewed and are written to satisfy contractual requirements, it was assumed in this study that professional reports were of better writing quality than student EDRs. Table 4.1 shows the composition of each corpus, including the number of texts collected (in person or online) from each professional database and each university engineering course. After all reports were collected, they went through several procedures to ensure (a) their representativeness of the targeted EDR genre and (b) the comparability of reports in the student and professional corpora. The following sub-sections first describe the sampling procedures for each corpus of the present study and then explain genre confirmation procedures carried out to ensure corpus representativeness.

Table 4.1 Initial composition of the corpora compiled for the study

Register	Source	Number of texts		Number of EDRs selected (before genre confirmation procedures)
		Collected	Rejected	
Professional EDRs	Department of Energy Information Bridge (DoE)[1]	69	43	26
	The Defense Technical Information Center(DTIC)[1]	44	23	21
	NASA Technical Reports Server (NTRS)[1]	50	18	32
	National Renewable Energy Laboratory (NTRS)[1]	27	14	13
	Engineer Research and Development Center (ERDC)[1]	23	17	6
	Total professional EDRs	*213*	*115*	*98*
Student EDRs	University 1 – Large public university[3]	55	0	55
	University 2 – Large public university[2, 3]	26	1	25
	University 3 – Small private, not-for-profit university[2]	37	13	24
	University 4 – Large public university[2]	266	148	122
	Total student EDRs	*384*	*161*	*226*
Total		**597**	**276**	**324**

[1] – Texts were collected in publicly available online governmental databases
[2] – Texts were collected from engineering senior capstone course websites
[3] – Texts were collected in senior capstone courses directly from students and/or their instructors

4.2.1 Professional EDR Corpus Design

The professional corpus for the study was compiled in two major steps. First, online databases containing professional EDRs were located, and then EDRs were sampled from these online databases. Figure 4.1 schematically shows the procedures used for the compilation of the full-text professional EDR corpus. As the figure illustrates, each of the two major steps included several smaller stages. The following description details all compilation procedures for the professional EDR corpus.

First, following Bowker and Peterson (2002), to construct a corpus of professional EDRs, a thorough online search was carried out. Because specific databases of solely EDRs could not be located, the search focused on engineering technical report (ETR) databases from which EDRs could then be sampled. The search included the use of search engines, such as Google, and the use of specialized resources and libraries, such as Science Reference Services (available at www.loc.gov/rr/scitech/trs/trsgencoll.html) and Databases and E-Resources (available at www.loc.gov/rr/ElectronicResources/subjects.php?subjectID=84&Submit=Select) at the Library of Congress. The researcher used the following keywords for the search of available technical report databases: "technical report," "engineering," "technology," "database," "R&D," and "project report." The results of the search produced a list of 34 databases, which contained either technical reports or technical reports along with other technical and scientific documents, such as research articles and presentations, in engineering and other disciplines. A complete list of databases found after the initial online search and their selection criteria for the study can be found in Appendix H.

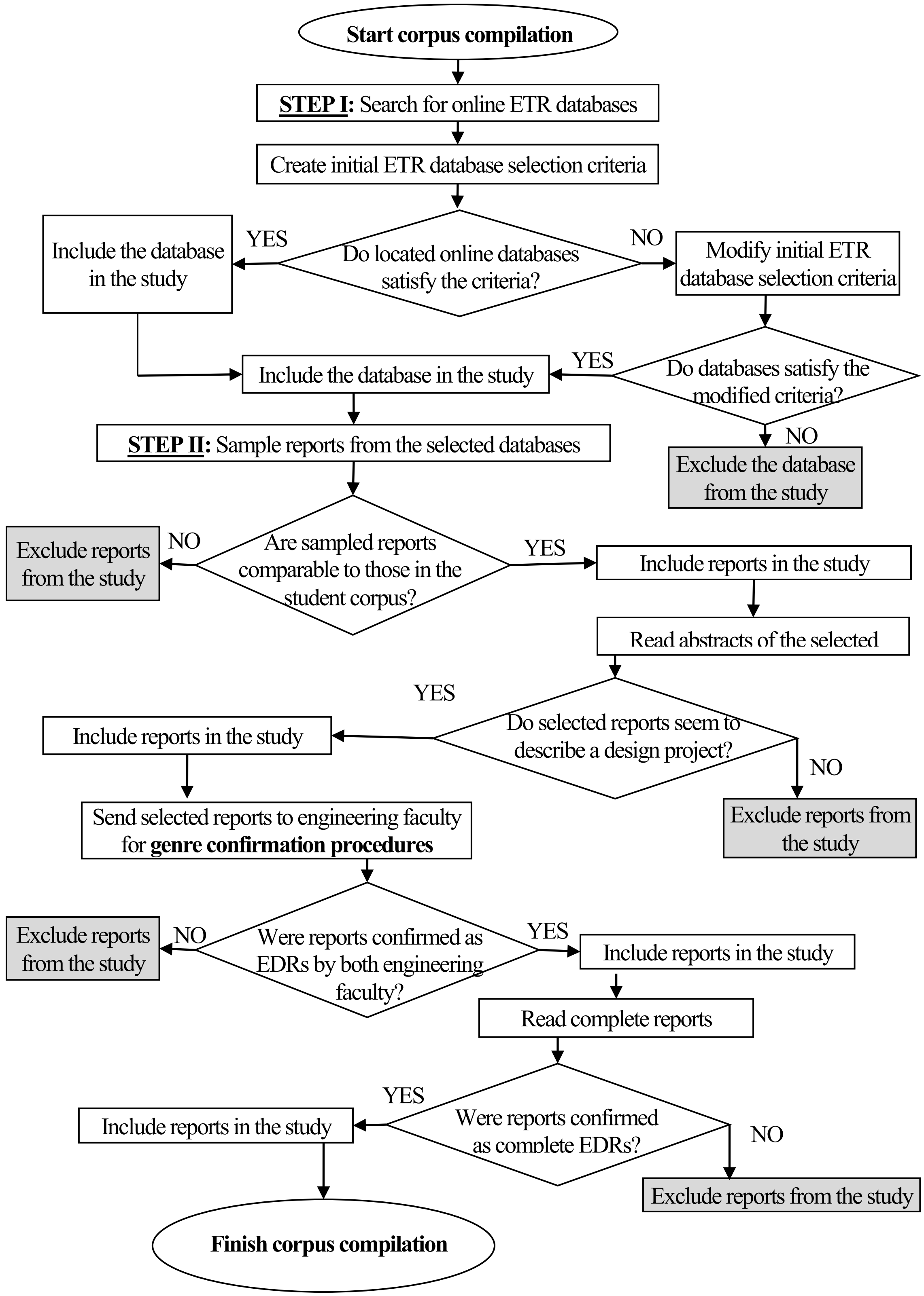


Figure 4.1 Procedures used to compile the full-text professional EDR corpus

In line with the goals of the present research, the following database sampling procedures were followed. In the first stage, initial selection criteria for the databases were specified and listed in a table (see Table 4.2). These criteria were necessary because some databases that were found through the search were not, in fact, technical report databases; rather, they contained ETRs, but also included other technical and scientific documents. Other databases were technical report databases, but contained technical reports from a variety of disciplines, including engineering. Further, some databases included "legacy" or "heritage" technical reports, which were written in various time periods (e.g., 1909–1958) and may not have been comparable to the much more recently written reports in the student corpus. Finally, some databases included reports written in other countries or languages; thus, their inclusion would have resulted in inaccurate comparisons with the student reports produced by upper-division university engineering students studying in the U.S.

After the initial list of database selection criteria was created, all the databases were scrutinized in more detail, and necessary information about each database was gathered. The results of this exploration showed that only one database satisfied all the initial database selection criteria, so the list of criteria was slightly modified (see Table 4.2). The second stage then involved applying the modified list of database selection criteria to only those databases that already met at least the first three selection criteria in the initial list (see Table 4.2). Thus, if the databases contained documents that were in the public domain, written in English in the U.S., and published after 2000, they were tested against the modified selection criteria. If a database did not satisfy any of those three criteria, it was not considered any further for the study. The results of this procedure reduced the number of databases suitable for the purposes of the study from 34 to 22.

Table 4.2 Initial and modified ETR database selection criteria

Original list of the selection criteria (used in Stage 1)	Modified list of the selection criteria (used in Stage 2)
1. The reports are in the public domain (i.e., they are not subject to additional fees or copyright laws). 2. The reports are published in English, and written in the U.S. 3. The reports are published not earlier than 2000. 4. The reports are technical reports (i.e., they come from a technical reports database). 5. The reports cover one of the disciplines of engineering (i.e., the database is engineering oriented).	1. The reports are available for download in either .pdf or .doc (rtf, txt) formats. 2. If a database includes reports written outside of the U.S, it should allow for a search of only reports written in the U.S. 3. If a database contains reports published earlier than 2000, it should include reports written after 2000 and enable a search by the year of publication. 4. If a database is not an exclusively technical reports database, it should allow for a "Publication Type" search and include technical reports. 5. If a database is not an exclusively engineering database, it should allow for a search of documents within a particular discipline and include engineering disciplines.

The 22 databases that satisfied the first three initial criteria for database selection were investigated further with the modified list of criteria. In particular, to be selected for further review, a database needed to contain reports available online in either .pdf or .doc formats and satisfy all but one of the five modified database selection criterion. Eleven databases satisfied these requirements and were further investigated. Of these 11, three computer science technical report databases were excluded after it was determined that computer science may not be considered by some engineering professionals to be an engineering discipline but rather a separate field (i.e., not engineering). Two additional databases were excluded because it was found that their reports were included in two larger databases that were also selected for the study. Finally, one database included only a few reports published in years 2000–2011, and these reports were titled either as literature reviews or recommendation reports; therefore, that database was also excluded from the study. Thus, the results of this last stage generated a short list of five databases that were ultimately selected for the study: Department of Energy Information Bridge (DoE), Engineer Research and Development Center (ERDC), NASA Technical Reports Server (NTRS), National Renewable Energy Laboratory (NREL), and the Defense Technical Information Center (DTIC). These databases contained reports that were written in English after 2000, by professionals in the U.S. These reports were technical and covered various engineering projects. Finally, they were in the public domain and available for download in either .pdf or.doc formats. All these databases contained reports written for government-sponsored research and development projects.

After the five databases with EDRs were identified, a table of random numbers was generated to randomly sample EDRs from these sources. However, because each of the selected ETR databases contained not only EDRs but other technical documents as well, random sampling proved to be an ineffective technique and was abandoned. Importantly, while some databases were more design-oriented, others proved to be more research-oriented, making it harder to collect EDRs from them. Therefore, titles and abstracts of reports in the research-oriented databases (i.e., ERDC and NREL) were examined, and reports that could potentially be EDRs were collected. This sampling technique, however, did not work well with more design-oriented databases, which contained numerous potential EDRs. Thus, in addition to examining reports' titles and abstracts, in design-oriented databases (i.e., DoE, DTIC, and NTIS) keyword searches with words "design," "development," and "device" were used to make sampling more effective. Finally, to ensure that professional EDRs were comparable to EDRs in the student corpus, only reports that (a) were multi-authored, (b) contained fewer than 50 pages of text and graphics, and (c) documented design project activities were selected for the study.

After the sampled reports were deemed comparable to those in the student corpus in terms of number of authors, number of pages, and design focus, an additional step was taken. Abstracts of selected reports were read by the researcher to confirm that the reports detailed work on completed engineering design projects; those reports that were describing ongoing or unfinished engineering design projects were excluded from the study. Thus, a corpus consisting of 98 professionally written EDRs was developed. After this initial corpus was compiled, genre confirmation procedures were carried out for all professional reports selected for the present study. The genre confirmation procedures are described in Section 4.3.

4.2.2 Student EDR Corpus Design

To create a corpus of student EDRs, a convenience sample was used. All student EDRs included in the corpus were (a) produced by senior-level engineering students enrolled in university capstone design engineering classes and (b) entailed a collective student-team effort. The student EDR corpus was collected in person and online from four universities in the U.S. The first sample of student EDRs was collected at a large urban public university in the U.S. (i.e., University 1) in academic years 2003–2004 and 2004–2005. The researcher, the only instructor of the writing workshops accompanying the capstone class, collected all the EDRs written by the students. As a result, 55 student EDRs were collected for this sub-corpus after IRB approval was received.

The second sample of student EDRs was collected in Spring 2010 at a midsize public university in the Southwestern U.S. (i.e., University 2). These EDRs partly consist of reports written by students enrolled in engineering capstone courses and partly of reports collected online from capstone course websites. To collect EDRs from students directly, after IRB approval was received, engineering professors and instructors teaching senior capstone design courses were contacted through electronic mail and asked to participate in the project. The classes of those professors and instructors who showed an interest in the study were later visited by the researcher who explained the study and distributed informed consent forms to the engineering students. At the end of the semester, engineering professors collected student EDRs electronically or in hard copies, and depending on their form, either sent these reports to the researcher through electronic mail or provided the researcher with hard copies, which later were scanned and saved as .pdf files. Eighteen EDRs written by groups of students were collected in this way. The remaining part of the University 2 sample consisted of seven student EDRs collected online from the capstone courses' websites. In total, 25 student EDRs were collected from University 2.

Student EDRs from two other sources (i.e., Universities 3 and 4) were collected in the Fall 2010 online by means of an internet search with the following keywords: "student," "design," "report," "final," and "project." As a result of this search, four additional sources of student engineering reports were found (see Appendix I). After a close examination of these sources (i.e., engineering course websites), however, EDRs from only two of these sources were included in the present study. The two excluded sources contained reports that did not satisfy the original criteria for inclusion;

specifically, these reports were either (a) research reports, (b) single-authored reports, or (c) reports on projects that were going to be carried out in the future, rather than completed design projects.

After this initial corpus was created, all student reports were checked against the report inclusion criteria, and only multi-authored, project-based student reports containing fewer than 50 pages of text and graphics were selected for the study. In total, 226 student EDRs were collected for the student EDR corpus. Similar to the reports in the professional corpus, all student EDRs were subsequently subjected to genre confirmation procedures to ensure that they were, in fact, EDRs. Table 4.3 shows the composition of the student EDR corpus.

Table 4.3 Composition of the student EDR corpus

Source	Source of EDRs	Basic Carnegie classification	Number of reports
University 1	Large public university	RU/H: Research Universities (high research activity)	55
University 2	Large public university	RU/H: Research Universities (high research activity)	25
University 3	Small private, not-for-profit	Bac/A&S: Baccalaureate Colleges – Arts & Sciences	24
University 4	Large public university	RU/VH: Research Universities (very high research activity)	122
		Total	**226**

4.3. Genre Confirmation Procedures

After professional and student reports were collected and compiled into two distinct corpora, the next step involved genre confirmation procedures. These procedures were needed to ensure that both corpora contained only EDRs. These steps were taken because all too often corpus-based studies examining less well-known professional genres simply assume that texts collected for analyses represent the target genre. These studies, especially those in the Language for Specific Purposes (LSP) tradition, then describe a genre's rhetorical structure (often using move analysis), linguistic features, and context in which such genre occurs. A major drawback of such research is the underlying assumption that all corpus texts belong to the target genre. Because genre confirmation procedures are typically not reported in this research, the results of such analyses raise questions about their validity.

In addition, because most genre-based studies do not describe the methodological procedures used to identify the genres under investigation but rather simply describe texts that are assumed to be of the target genre, there is a general lack of methodological guidance on carrying out genre confirmation procedures (cf. Askehave & Swales, 2001). This observed lack of methodological direction in genre confirmation is similar to that reported by Wilde, Giess, and McMahon (2009). These scholars attempted to apply faceted classification principles to the description of engineering design documents produced within one company and found lack of specification of expected or needed methodological activities and a lack of agreement about theoretical constructs on which this analysis was based.

Developing clear genre confirmation procedures was crucial for the present research because it was expected that the sources from which EDRs were obtained could have contained a variety of documents, only some of which would be EDRs. The genre confirmation procedures used in the study consisted of three stages: (a) examination of collected reports by the researcher, (b) creation of two Excel files with information (listed below) about professional and student EDRs, and (c) review of information about each report in the two Excel files by two collaborating engineering faculty.

First, each report was examined by the researcher to verify that (a) it reflected work on an engineering design project and (b) this work led to the development of an artifact. Reports that did not satisfy these two requirements were excluded from the study. Second, to confirm that the remaining reports were, indeed, EDRs, all reports collected from professional databases and engineering capstone courses were entered into two Excel files (one for professional and one for student reports). Each file contained the following information about each report: (a) the artifact being designed in the project, and (b) a short project description. Figure 4.2 shows a snapshot of the Excel file with professional EDRs.

File name	# of pages	Artifact	EDR	Disciplines	Comments
Pr1_00_1	14	Cost effective composite drill pipe			
Pr1_00_2	25	Piezoelectric motor connection method			
Pr1_00_3	13	Laser driven photocathode injector light sources			
Pr1_00_4	13	Optical cell designs for high-pressure and high-temperature fluid research			
Pr1_01_1	31	Multiport cylinder dryer			
Pr1_01_2	16	Frequency selective surface (FSS) structure			
Pr1_02_1	13	Internal circular compression band restraint device			
Pr1_02_2	25	Fully integrated PV system for residential applications			
Pr1_03_1	21	System to provide diagnostics-while-drilling			

Elenka:
This report presents the design and evaluation of electrical connection methods for driving an 8-millimeter traveling wave piezoelectric ring motor. This proved to be a difficult problem because many of the electrical leads and the bonds attaching them to the PZT ceramic were subject to breaking due to resonant vibrations as the motor was run. Methods investigated to provide electrical leads to the PZT ceramic ring included discrete wires, custom-designed cables, and a fixed ceramic ring. Bonds to the ceramic ring were made using three conductive adhesives, thermosonically bonded gold jumper wires, and soldering. A scanning laser Doppler vibrometer was used to evaluate the resonance in the electrical leads. Finite element analysis was used to help guide the design of a new cable to eliminate the resonance problems.

Figure 4.2 Snapshot of the professional EDR Excel file

The two Excel files were then sent to two collaborating engineering faculty members, who, at the time of the study, had more than 10 years of university engineering teaching experience each and who specialized in two different engineering disciplines: mechanical and electrical engineering. The faculty were instructed to read the artifact depiction and project description provided for each report in order to (a) confirm that the report was an EDR and (b) determine with which engineering discipline(s) each artifact, and, in turn, report was most closely aligned. To designate the engineering disciplines most closely aligned with the artifact and report, faculty could choose from a list of 27 engineering disciplines (Table 4.4), a list adopted from ABET 2010 Criteria for Accrediting Engineering Programs (available at www.abet.org).

Table 4.4 Engineering disciplines used for genre identification procedures

Engineering disciplines	Code used for the discipline
Aerospace Engineering	AERO
Agricultural Engineering	AGRI
Architectural Engineering	ARCH
Bioengineering and Biomedical Engineering	BIO
Biological Engineering	BIOL
Ceramic Engineering	CERA
Chemical, Biochemical, Biomolecular Engineering	CHEM
Civil Engineering	CIV
Construction Engineering	CONS
Electrical and Computer Engineering	ELEC/COMP
Engineering, General Engineering, Engineering Physics, Engineering Science	GENE
Engineering Management	EMAN
Engineering Mechanics	EMEC
Environmental Engineering	ENVI
Geological Engineering	GEO
Industrial Engineering	INDU
Manufacturing Engineering	MANU
Materials and Metallurgical Engineering	MATE
Mechanical Engineering	MECH
Mining Engineering	MINE
Naval Architecture and Marine Engineering	NAVA
Nuclear and Radiological Engineering	NUCL
Ocean Engineering	OCEA
Petroleum Engineering	PETR
Software Engineering	SOFT
Surveying Engineering	SURV
Systems Engineering	SYST

Thus, each report in the study's two Excel files was reviewed electronically by the two engineering faculty who (a) determined whether each report was an EDR or not and (b) identified engineering discipline(s) most closely aligned with each EDR's artifact. Figure 4.3 shows a snapshot of the student EDR Excel file with one faculty's responses in highlighted columns. The faculty's responses about whether each report was an EDR or not were compared with the purpose of calculating inter-rater agreement.

File name	# of pages	Artifact	EDR	Disciplines	Comments
St4_05_1	23	Underwater remotely operated vehicle	y	mech	
St4_05_2	30	The resistor sorter	y	elec	
St4_05_3	22	The shuttle tracker	y	civ	
St4_05_4	27	Low-cost monitoring system for use on a generic green roof	y	envi	
St4_05_5	12	Algorithm that models stained glass in a physicallyrealistic manner	y	comp	
St4_05_6	40	Design of a special collections library	y	cons	
St4_05_7	30	'Helicopter' control theory demonstrator	y	elec	
St4_05_8	20	User-friendly stormwater pollution model	y	civ	
St4_05_10	27	Broad-spectrum oprtical multipurpose blood-monitor (SwatBOMB)	y	bio	
St4_05_11	32	Pedestrian bridge located at a retirement community	y	civ	
St4_05_12	22	Rune, the robot-user nexus	y	comp	
St4_05_13	17	Ball and beam control theory demonstrator	y	elec	
St4_05_14	14	Indoor robotic blimp for urban search and rescue tasks	y	elec/mech	

Figure 4.3 Snapshot of the student EDR Excel file with faculty's responses

Notably, the initial responses of the two faculty members about what constitutes an EDR differed. In particular, while one faculty member's responses closely corresponded to the researcher's decisions to assign these selected reports to the EDR genre, the responses provided by the second faculty member were rather inconsistent with both the researcher's decisions and the first faculty member's responses. Therefore, it was decided that an in-person meeting with this engineering faculty participant was necessary to improve our mutual understanding of the EDR genre. During the meeting, the researcher and the faculty member reviewed initial responses and examined in more detail (i.e., beyond the information provided in each short project description) those reports that were initially classified by this faculty participant as non-EDRs to confirm whether these reports were, in fact, non-EDRs.

Most of the reports that were examined at this face-to-face session had been previously classified by the faculty informant as non-EDRs because he considered them to be ongoing, not completed projects. Specifically, to explain his decisions, the faculty had marked such reports as "report of development" or "ongoing research." The classification of such reports as non-EDRs can be explained by the wording of the abstracts provided by the reports' authors. Indeed, even though these reports provided a description of completed projects, their abstracts included sentences such as the following, making the faculty member believe the project was still ongoing: "This project will lead [to the] development of ultrafast x-ray dynamics research on problems important in physics, chemistry, biology, and materials." Other abstracts focused on objectives for the project, suggesting that the whole document was a proposal rather than a description of a completed project, such as in

> This study aids in developing the photocatalyst technology that has potential for use in abatement of NOx. The objective of the proposed project is to apply the principles of chemical engineering fundamentals -- reaction kinetics, transport phenomena and thermodynamics -- in the process design for a system that will utilize a photocatalytic reactor to oxidize NOx to nitric acid (HNO3).

Upon closer examination (i.e., beyond the information in the reports' abstracts or short descriptions), however, these projects, which were initially labeled as "ongoing" by the expert informant, described their methodology and results and culminated in the design of a particular artifact, thus qualifying them to be classified as EDRs. Therefore, after these reports were reexamined with the engineering faculty member, most were reclassified by this participant as EDRs.

This step ensured that the researcher and two engineering faculty informants had a similar understanding of the EDR genre and resulted in a high percent of agreement for the professional corpus (92.86%) and the student corpus (96.90%). In particular, of the 98 reports collected for the professional corpus, 90 were confirmed by both faculty members as EDRs and 1 report as a non-EDR; seven reports were identified as EDRs by one faculty but not the other. In the student corpus, of 226 reports collected, 6 were identified as non-EDRs by one faculty but not the other and 1 report was identified as a non-EDR by both faculty members. The process resulted in the exclusion of eight professional and seven student reports.

Finally, all reports were thoroughly read in their entirety. More specifically, all professional EDRs were read by the researcher and a recent engineering graduate recommended by several engineering faculty from the researcher's home institution. At least 10 student EDRs from each university were read by the researcher and either a recent engineering graduate or a current (at the time) engineering graduate student recommended by the same engineering faculty. All the remaining student reports were read by the researcher only. As the result, 13 EDRs in the professional corpus and 32 reports in the student corpus were excluded from the study because they either did not contain design methods, did not describe completed testing procedures for designed prototypes, and/or were not completed projects.

The genre confirmation procedures discussed in this section ensured that the corpora compiled for the present study contained EDRs and that these engineering projects were completed designs leading to the production of particular artifacts. Table 4.5 shows the composition of the professional and student EDR corpora before and after the genre confirmation procedures.

Table 4.5 Composition of the EDR corpora before and after genre confirmation procedures

Register	Number of texts: Collected	Rejected during abstract reading by two faculty	Additional EDRs rejected during thorough report reading	Number of EDRs selected for the study
Professional EDRs	98	8	13	77
Student EDRs	226	7	32	187
Total	324	15	45	264

4.4. File Conversion and Clean-Up

After student and professional EDR corpora were subjected to genre confirmation procedures, each file was converted to plain text. In the process of file conversion, two student EDRs were removed from the corpus because it was impossible to extract text from them due to poor text recognition. Then each text was manually edited. In this editing process, all page headers and footers (typically containing the governmental agency or engineering course title and number, EDR title and author name, and/or a page number) were deleted because they are not a part of the language of the report itself. In addition, all text that was not considered to be part of the description of the engineering project was deleted from the files, including all disclaimers, notices, report documentation pages, acknowledgements, distribution lists, tables of contents, lists of terms, footnotes, reference lists, and appendices. Further, many EDRs contained formulas and special symbols throughout the texts. Each text was edited using the following principle: formulas set apart from the text of the article on their own lines were removed. If, however, a short formula or symbol was embedded in the prose of the article, it was retained. Finally, all tables and figures were also deleted from the files because they also did not contain the language of the report itself. All text files were given a descriptive filename containing indicators of the report source (i.e., particular online database or university), the year of publication or submission in class, and a unique identification number (e.g., Pr1_02_3 or St2_06_5).

4.5. Corpus Description

The final corpora comprise a total of 262 EDRs. The professional corpus consists of 77 EDRs obtained from five publicly available online databases; the student corpus comprises 185 student EDRs collected from four universities. Table 4.6 displays the number of texts and words per corpus and source of EDRs.

Table 4.6 Final composition of the EDR corpora compiled for the study

Register	Source	Number of texts	Number of words
Professional EDRs	Department of Energy Information Bridge (DoE)	22	82,343
	The Defense Technical Information Center (DTIC)	18	78,223
	NASA Technical Reports Server (NTRS)	27	74,584
	National Renewable Energy Laboratory (NTRS)	6	43,804
	Engineer Research and Development Center (ERDC)	4	30,540
	Total professional EDRs	***77***	***231,271***
Student EDRs	University 1 – Large public university	55	157,062
	University 2 – Large public university	24	133,982
	University 3 – Small private, not-for-profit university	18	107, 009
	University 4 – Large public university	88	596,871
	Total student EDRs	***185***	***887,915***
Total		**262**	**1,119,186**

Table 4.7 shows the composition of the EDR corpora by engineering discipline, based on independent ratings by the two engineering expert informants. The unclear category is used for those cases when the ratings of the engineering experts did not match. As can be seen, most artifacts, and, in turn, reports in the professional corpus are most closely aligned with the mechanical engineering discipline. In the student corpus,

most artifacts, and, therefore, EDRs were found to be most closely aligned with the discipline of electrical engineering. It is also worth noting that in both corpora, there are many EDRs, for which the engineering experts' ratings did not coincide. In fact, the experts' opinions about EDR discipline(s) differed for 28.6% of professional EDRs and 20.5% of student EDRs.

Table 4.7 Composition of the EDR corpora by engineering discipline

Source of EDRs	Number of texts by discipline								
	Bio	Comp	Civ	Elec	El/Me	Envi	Mech	Nucl	Unclear
Department of Energy Information Bridge		1		5		1	12	1	2
The Defense Technical Information Center		2		2		1	5		8
NASA Technical Reports Server		1		8	1		11		6
National Renewable Energy Laboratory				3			1		2
Engineer Research and Development Center									4
Total professional EDRs		***4***		***18***	***1***	***2***	***29***	***1***	***22***
University 1		1	1	25	6		8		14
University 2		1	11	3		2	5		2
University 3		2	4	5	1	1	2		3
University 4	1	35	1	32					19
Total student EDRs	***1***	***39***	***17***	***65***	***7***	***3***	***15***		***38***

CHAPTER 5. METHODS USED FOR THE LINGUISTIC AND GENRE ANALYSES OF ENGINEERING DESIGN REPORTS

5.1. Introduction

The present study examines and compares core lexico-grammatical features and linguistic features associated with grammatical complexity in engineering design reports (EDRs) written by professional engineers in the workplace and those produced by students in upper-division engineering courses. To further investigate the EDR genre and provide a more detailed description of effective EDRs, the present study both draws on the ESP tradition of genre analysis and utilizes corpus-based methodologies to (a) determine conventional discourse structures of professional EDRs and (b) identify linguistic features that are associated with particular EDR organizational units.

This chapter introduces the methodological steps used for the linguistic and rhetorical analyses of the study. Section 5.2 explains the methodological procedures used in the linguistic analyses of the study, including corpus processing, norming of the rates of occurrences of all linguistic features used in the analyses, and selection of linguistic features used for analyses. Section 5.3 then presents the methodological steps used for the genre analysis of professional EDRs, first outlining the general approach to genre analysis taken in the present study and then detailing specific genre analysis procedures.

5.2. Linguistic Analyses

The linguistic analyses used in the present study to compare EDRs written in professional and academic settings included a survey of the core lexico-grammatical features in both corpora and an investigation of linguistic features associated with grammatical complexity. Specifically, the linguistic analyses conducted for this study are based on a range of linguistic features, including major content classes (i.e., nouns, verbs, adjectives, and adverbs), lexical classes of nouns and verbs, personal pronouns, passive voice, tense and aspect marking of verb phrases, and modals. The linguistic analyses also survey features associated with grammatical complexity, including vocabulary size (operationalized as type/token ratio), average word length, nominalizations, prepositions, conjunctions and coordinators, and complement clauses.

This section details the methodological steps used in the linguistic analyses of both (a) student and professional EDRs, whose results are presented in Chapter 6, and (b) major rhetorical units of professional EDRs, whose results are described in Chapter 7. Specifically, the section first discusses the corpus annotation procedures that enabled subsequent automatic analyses available with corpus linguistics techniques. Next, the section explains norming of the rates of occurrences of the linguistic features. The section then presents a rationale for the selection of linguistic features used for the analyses of EDRs and illustrates these features with examples.

5.2.1 Corpus Processing

To enable automatic analyses available with corpus linguistics techniques, the two corpora were annotated with grammatical and lexical information for each word in the texts. All EDRs were 'tagged' for parts of speech (POS) and semantic categories using the Biber tagger, a computer program developed by Biber (see Biber, 1988; Biber et al., 1999) to automatically assign 'tags' that indicate grammatical information for each word in a text. Tagging was crucial for the present study as it allows for detailed grammatical and lexical annotations necessary for the subsequent corpus analyses. The Biber tagger uses large dictionaries, lexical information, probabilistic information, and contextual rules to assign tags for the major parts of speech (e.g., noun, verb, adjective, adverb), verb tense, aspect and voice (e.g., active vs. passive, perfect aspect, modality), and syntactic structures (e.g., *that*-clauses, *to*-clauses, conditional clauses). According to the American National Corpus website (2007), the Biber tagger has an average accuracy similar to most taggers (95% or higher).

A complementary "tagcount" program, also created by Biber, automatically provides normalized counts per single file of 120 grammatical or semantic features based on a combination of lexical information and grammatical tags provided by the Biber tagger. Biber (2006a) lists many of the features identified in this tagcount program (see Appendix A in Biber, 2006a). Finally, the WordSmith Tools 4 concordancing program (Scott, 2004) was utilized to aid in interpreting the data through the use of key-word-in-context (KWIC) lines to investigate the use of linguistic features.

5.2.2 Norming

The rates of occurrences of all linguistic features used in the analyses in this study were normed per 1,000 words. In typical quantitative research, norming is necessary to correctly compare the distribution of linguistic features across texts or corpora with varying lengths or sizes (i.e., number of words) (Biber, Conrad, & Reppen, 1998). The normed frequency counts per 1,000 words were used to be consistent with the tag counted results from Biber's tagcount program. To calculate a normed rate of occurrence, the total raw frequency of a feature is divided by the total number of words in the text or corpus (depending on the unit of observation), and then multiplied by a norming number, typically 1,000 or 1 million (see Biber, Conrad & Reppen, 1998, pp. 263–264).

In order to report rates of occurrence of linguistic features for professional and student EDRs using per-text counts, the normed rates of occurrence for all of the texts representing professional and student EDRs were averaged. Using a mean rate of occurrence for a linguistic feature minimizes the effect of a few texts that use a linguistic feature in a markedly different way quantitatively. In addition, because per-text counts are used, if necessary, the standard deviation can be calculated along with the mean to describe the variability within the texts representing a register.

5.2.3 Linguistic Features Used for Analyses

The primary goal of the present dissertation research is to characterize student and professional EDRs in terms of their linguistic patterning. Another goal of the study is to typify professional EDRs by determining their typical organization and identifying linguistic features associated with major rhetorical units of EDRs. To achieve these goals and to create a comprehensive description of language variation between the two EDR registers (and across rhetorical units within professional EDRs), the study considered a wide range of linguistic features. In particular, previous research on linguistic variation has shown that one of the main differences across spoken and written registers is related to the use of content word classes, such as nouns, verbs, adjectives, and adverbs (Biber, 1988; Biber, 2006a). These studies have shown that generally written registers rely to a much greater extent on nouns and adjectives whereas spoken registers tend to rely on nouns and verbs to similar extents but show a higher density of adverbs.

However, little current research on EDRs exists in general, and even less is known about linguistic variation in EDRs written in different settings. This study addresses this gap by examining core grammatical features that have been shown to vary across multiple registers in previous research. In addition, the study investigates typical lexical patterns within some of these grammatical categories. It was expected that less variation in the overall use of the core content word classes would be found between the EDR registers (and across EDR rhetorical units) because previous linguistic analyses of general grammatical features were based on comparisons of spoken and written academic registers, which differ in their situational characteristics to a much greater extent than the EDR registers examined in the present study. Further, it was expected that EDR registers would show overall trends corresponding to previous findings regarding an overall greater reliance of written registers on nouns and adjectives, and less so on verbs and adverbs. Table 5.1 shows core lexico-grammatical features examined in the present study and provides their examples.

In addition, the linguistic analyses of EDRs explored several features associated with grammatical complexity. Specifically, previous research (Biber, 1988; Friginal, 2008, 2009) suggests that vocabulary size (operationalized as type/token ratio) and average word length indicate lexical specificity; frequent use of nominalizations signals information density; and a high density of prepositions, conjuncts, and complement clauses points toward syntactic complexity. This set of features was examined in the present study. Though a higher rate of occurrence of these measures in combination is not a precise measure of grammatical complexity, it may suggest greater overall grammatical complexity of discourse.

Table 5.1 Grammatical categories included in the analysis with examples

A. Nouns	
1. All nouns	*program, rain, room, book, child*
2. Semantic sets of nouns	
Abstract nouns	*background, criteria, quality, religion, setting*
Animate nouns	*applicant, child, owner, person, scientist, user*
Cognition nouns	*decision, concept, fact, idea, knowledge, reason*
Concrete nouns	*target, piece, textbook, equipment, map, manual*
Group nouns	*company, institute, school, university*
Place nouns	*building, campus, location, museum, park, road*
Process nouns	*description, employment, production, training*
Quantity nouns	*half, month, number, rate, today, volt, volume*
Technical nouns	*compound, data, formula, sample, solution, unit*
B. Pronouns	
All pronouns	*we, you, they, this, some, yourself, mine, our, all*
1st person	*I, we*
2nd person	*you*
3rd person	*he, she, they*
C. Verbs and verb phrases	
1. All verbs	*runs, have developed, is specified, wrote, create*
2. Semantic sets of verbs	
Activity verbs	*bring, combine, encounter, open, produce*
Aspectual verbs	*begin, end, start, continue*
Causative verbs	*help, enable, ensure, require*
Communication verbs	*acknowledge, claim, discuss, suggest*
Mental verbs	*believe, know, predict, think*
Occurrence verbs	*become, grow, increase*
3. Passive voice verbs	
Agentless	*is ascribed to X, have been analyzed*
By-phrase	*are accompanied by X, were provided by X*
D. Modals	
1. All modals	*can, could, must, shall, should, will, may*
2. Possibility modals	*can, could, may, might*
3. Necessity modals	*must, should*
4. Prediction modals	*will, would, shall*
E. Other classes	
1. Adjectives	*central, different, evident, general, critical, old*
2. Adverbs	*also, certainly, effectively, frankly, mainly, often*

5.3. Genre Analysis

This section describes methodological procedures used in the genre analysis of professional EDRs. Section 5.3.1 first explains the general descriptive approach to genre analysis followed in the present study. Section 5.3.2 then details genre analysis procedures, including the coding scheme developed for the EDR genre analysis, coder selection and training, and individual coding sessions.

5.3.1 Descriptive Approach to Genre Analysis

To study genres for pedagogical purposes similar to those of the present study of EDRs, most researchers use textual approaches to genre, of which Swales's (1990) move analysis has been the most influential. Move analysis seeks to examine the general organizational patterns of analyzed texts, which consist of sequences of moves, or functional units that together fulfill a genre's overall communicative purpose. Moves can be required (i.e., frequently used and thus conventional) or optional (i.e., not used as frequently). They typically contain at least one proposition but greatly vary in length. Moves can follow a very strict sequence or occur in a less predictable order. They can be composed of several elements, called *steps* by Swales (1990), that realize the move.

One example of the traditional move analysis is Swales' Create a Research Space (CARS) model. Created to depict research article (RA) introductions, the CARS model includes three moves (Establishing a Territory, Establishing a Niche, and Occupying a Niche), each consisting of several steps. In move 1, Establishing a Territory, RA authors show the importance of their research area. Then RA authors typically transition to move 2, Establishing a Niche, where they identify gaps in the field, such as unanswered questions or inadequately researched areas. Here authors generally cite relevant literature to justify their claims and to connect the current work to other research efforts. Finally, in move 3, Occupying a Niche, RA authors introduce the current work and often explain how gaps identified in previous studies are addressed. This sequence, however, may vary between different instances of a genre, that is, some moves may be optional whereas some may occur in a different order, be embedded in others, or be repeated.

Despite its influential status, move analysis has been the target of several criticisms. One such criticism is related to the labor-intensive nature of move analysis, which frequently leads to analyses of a small number of and/or incomplete texts, thus making it hard to generalize findings of such analyses. Further criticisms of move analysis are linked to its methodology of coding move types and the focus of the analysis itself. In particular, move boundaries are semantically determined; therefore, lack of explicit protocols for identification of move boundaries often reflects subjective judgments, which lead to questions about the reliability and validity of the analysis (Kanoksilapatham, 2005; Paltridge, 1994). Finally, by focusing on such well-researched and highly conventionalized genres as scientific RAs, RA introductions, and RA abstracts, move analyses encourage us to believe that the structure of genres is largely straightforward and linear, when, in fact, this may be far from reality. Frequently, genres that are not as highly conventionalized and allow a certain degree of flexibility (Dressen, 2002; Loudermilk, 2007).

In such cases, a traditional move analysis might not be the most appropriate method of genre analysis; instead, one would want to develop a model of a genre which, "while retaining the descriptive power of authorial intention and the strategic move, would also remove the content-based constraints imposed by discoursal linearity and the step-by-step construction of the CARS model on the description of the linguistic data" (Dressen, 2002, p. 150). The descriptive design, thus, is used to "observe, describe, and document aspects of a situation as it naturally occurs" (Polit & Beck, 2004, as cited in Ford, 2009) and is typically employed when the researched characteristics are either unknown or partially known. Results of such descriptive investigations often serve as a starting point for future investigations. Because no previous studies of EDRs have examined this genre's discourse structure or language and because studies of this genre are very limited, the descriptive approach to genre analysis of EDRs appeared to be particularly suited for the present dissertation research. The next section discusses procedures associated with such a descriptive approach in the present study.

5.3.2 Genre Analysis Procedures

The descriptive genre analysis presented here follows the general methodological steps of a move analysis described in previous research (Biber, Connor, Upton, & Kanoksilapatham, 2007; Kwan, 2006). Biber, Connor, Upton, and Kanoksilapatham (2007) identify 10 general steps that are frequently used for a corpus-based move analysis. These steps have been modified to fit the design of the present study. Table 5.2 shows modified steps of the descriptive genre analysis that were followed in the study.

Note that the study uses the term *organizational unit* instead of the more common term *section* because it was found that most EDRs contain organizational units that are not labeled according to well-known conventions found in research articles. Further, major EDR organizational units may, in fact, contain several sections, making it harder to apply conventional section labels to these rhetorical structures. For example, an EDR may contain two (or more) fully developed rhetorical structures on the development of different components of a device (e.g., Software and Hardware). Each of these developed structures can be labeled a Methods section on its own; in the present study, all such units are collectively referred to as the Methods organizational unit.

Table 5.2 General steps for a descriptive genre analysis

Step	Description
Step 1	Determining rhetorical purposes of the genre
Step 2	Determining rhetorical function of each major organizational unit in its local context; identifying possible and maybe optional moves within a major unit
Step 3	Grouping functional and/or semantic themes that are either in relative proximity to each other or often occur in similar locations in representative texts. These reflect the specific moves that can be used to realize broader, major organizational units
Step 4	Conducting pilot-coding to test and fine-tune definitions of organizational units' purposes
Step 5	Developing a coding protocol with clear definitions and examples of major, obligatory organizational units and smaller and perhaps optional moves
Step 6	Coding full sets of texts, with an inter-rater reliability check to confirm that there is clear understanding of organizational unit and move definitions and how they are realized in texts
Step 7	Adding any additional moves that are revealed in the full analysis
Step 8	Revising coding protocol to resolve any discrepancies revealed by the inter-rater reliability check or by newly discovered moves, and re-coding problematic areas
Step 9	Analyzing linguistic features of organizational units and moves
Step 10	Thoroughly describing corpus of texts in terms of typical and alternate organizational units and moves and their linguistic characteristics

To increase accuracy of organizational unit and move identification and thus ensure high reliability of coding procedures and results of the analysis, careful consideration was given to coding scheme preparation, coder selection, coder training, coding practice sessions, and independent coding. These important elements of the analysis are discussed in detail below.

5.3.2.1. Coding Scheme

Move analysis, developed by Swales (1990) and briefly discussed in Chapter 2, seeks to examine the general organizational patterns of analyzed texts. A general organization of a text consists of sequences of moves, or functional units, that together fulfill a genre's overall communicative purpose. Moves can be required (i.e., frequently used and thus conventional) or optional (i.e., used not as frequently). They typically contain at least one proposition but greatly vary in length. Moves can follow a very strict sequence or occur in a less predictable order. Importantly, moves typically have distinct linguistic boundaries that can help researchers more objectively identify them in the analysis (Kanoksilapatham, 2012). Thus, for the genre analysis in the present study, organizational unit and move identification relied on several sources of information: linguistic evidence, general text comprehension, and an understanding of the expectations of the engineering discourse community (Dudley-Evans, 1994; Nwogu, 1997).

An analytical framework, or coding scheme, was developed to enable reliable identification of organizational units and moves in professional EDRs and control for possible variations in coding. The coding scheme was developed during Steps 2 – 5 of the genre analysis (see Table 5.2 in Section 5.3.2). Because there are no move-based analyses of the rhetorical organization of EDRs, several sources of information were used here, including textbooks and guides on technical and engineering writing (ANSI/NISO, 2005; Beer & McMurrey, 1997; ERDC, 2006; Finkelstein, 2005; GLISC, 2007; Roden & Murphy, 2009; Sorby & Bulleit, 2006), studies of engineering written discourse and especially those examining engineering technical and design reports (Anthony, 1999; Bartholomew, 1993; Dalton, 2008; Flowerdew, 2004, 2008; Krishnan & Kathpalia, 2002;

Marshall, 1991; McKenna, 1997), and genre-based empirical studies of written discourse in other disciplines (Brett, 1994; Bruce, 2008; Hopkins & Dudley-Evans, 1988; Kanoksilapatham, 2003, 2005; Kwan, 2006; Yang & Allison, 2003).

The EDR coding scheme was developed in several stages and modified during the analysis. The initial coding scheme was (a) used for a coder training tutorial, (b) modified during coder training sessions, and (c) used in its revised version for independent coding by the researcher and two coders who assisted with this research. The initial coding scheme developed for the study contained 8 organizational units and 17 moves, which were selected after a thorough literature research on EDRs (see sources above) and the situational analysis carried out for the present study (Poltavtchenko, 2010a).

The initial coding scheme was modified during the coding process to account for patterns that emerged and to clarify ambiguities identified during coding. For example, the move initially labeled the Description of Materials was later split into two moves, one describing how design components look and what they consist of (labeled Physical Description of Materials or DOM Physical) and another move focusing on the depiction of how design components work (labeled Functional Description of Materials or DOM Functional). Although both these moves describe materials, it was soon realized that these descriptions differ and utilize different linguistic devices. These observations and subsequent discussions among all coders led to the changes in the coding scheme. Both the initial and modified coding schemes are presented in Table 5.3. The complete coding scheme used in this study along with examples from the EDR corpora is presented in Appendix K.

Table 5.3 Initial and modified coding schemes

Initial coding scheme used for the training session	Modified coding scheme used for individual coding
ABSTRACT	ABSTRACT
	CONCLUSION
EXECUTIVE SUMMARY	DISCUSSION
	EXECUTIVE SUMMARY
INTRODUCTION	INTRODUCTION
Background	METHODS
Problem statement or need for project	METHOD AND RESULTS
Previous work by others	RECOMMENDATIONS
Current design	RESULTS
Overview of the report	RESULTS AND DISCUSSION
	Assumptions
METHODS	Background
Previous work by authors	Current design
Procedures	Description of materials: Functional
Description of materials	Description of materials: Physical
	Evaluation
RESULTS	Follow-up activities
Testing and analysis results	Implications
Optimization or troubleshooting	Lessons learned
	Need for project
DISCUSSION	Optimization and/or troubleshooting
Implications	Overview of the report
Problems encountered	Planning and project management
Follow-up activities	Potential problems
	Previous work
RECOMMENDATIONS	Problems encountered
Future directions	Procedures
Recommendations	Project summary
	Recommendations
CONCLUSION	Requirements and constraints
Summary	Results
Evaluation	Section blurb
	Specifications
	Summary
	Testing equipment
	Testing procedures

Note: The words in uppercase indicate major organizational units; the words in lowercase indicate moves.

As can be seen, an attempt has been made in the initial coding scheme to assign moves to specific EDR units. During the coding process, however, it soon became apparent that although individual moves tend to occur more frequently in particular units, they may sometimes appear in other organization units as well. Further, the qualitative data analysis program Atlas.ti 6.2 used for coding moves (described below in Section 5.3.2.3) also favored the less structured organization of moves shown in the right-hand column of Table 5.3. Therefore, it was decided for the modified coding scheme to arrange moves alphabetically and include their brief description along with a few move examples (see Appendix K).

5.3.2.2. Coder Selection

The lack of clear, explicit rules for the identification of move boundaries highlights the subjectivity of decisions made during the genre analysis. This subjective nature of judgments, in turn, leads to questions about reliability and validity of such qualitative research (Kanoksilapatham, 2005; Paltridge, 1994). Despite these concerns about the subjectivity of the genre analysis in the ESP tradition, only a few studies (Chang & Kuo, 2011; Crookes, 1986; Kanosilapatham, 2003) have reported the use of multiple coders or coder training to establish or improve the reliability of coding. To address these concerns and increase the reliability of EDR unit and move identification, two collaborating coders were asked to read a subset of the EDRs from the professional EDR corpus and identify major organizational units and moves with the coding scheme developed for the study. Subsequently, all professional EDRs in the corpus were read by at least the researcher and one of the coders..

Several factors have been reported to influence reliability of qualitative decisions, such as the ones made during genre analysis or writing ratings, including (a) the instrument used to make such decisions, (b) background of people who use the instrument, and their training in using it (Weigle, 2002). Therefore, to improve inter-rater reliability, it is important to carefully select and train coders, use at least two coders to code a relatively large sample of texts, and use a coding scheme with examples of organizational units and moves when coding. Thus, it was essential to consider who the collaborating coders would be (i.e., specialists in engineering or linguists). Following Kanoksilapatham (2003), the study used content specialists as coders to capitalize on the coders' engineering experience and expertise in reading and writing EDRs.

The coders were recommended by engineering faculty at the researcher's home institution. Both coders had received a bachelor's degree in engineering; one in mechanical engineering and the other one in civil engineering. At the time of their involvement in the study, one coder had already completed three semesters in an engineering master's program while the other one had worked in an engineering firm for over a year and had served as a grader in several engineering faculty's courses. Both coders were familiar with the EDR genre and had reported reading and writing EDRs in the past.

5.3.2.3. Qualitative Data Analysis Program Used for the Genre Analysis

To facilitate the coding and make it easier to use the results of the genre analysis for the subsequent unit-based corpora compilation, the study used a qualitative data analysis (QDA) program Atlas.ti 6.2. The purpose of Atlas.ti is to help researchers uncover and systematically analyze complex phenomena hidden in text and multimedia data. The program provides tools that let the user locate, code, and annotate findings in primary data material, to weigh and evaluate their importance, and to visualize complex relations between them. Atlas.ti consolidates large volumes of documents and keeps track of researcher's notes, annotations, codes and memos in all fields that require close study and analysis of primary material consisting of text, images, audio, and video. In addition, it provides analytical and visualization tools designed to open new interpretative views on the material. Figure 5.1 shows a screenshot of the Atlas.ti, with left-hand margins displaying codes used in the analysis of a particular text segment.

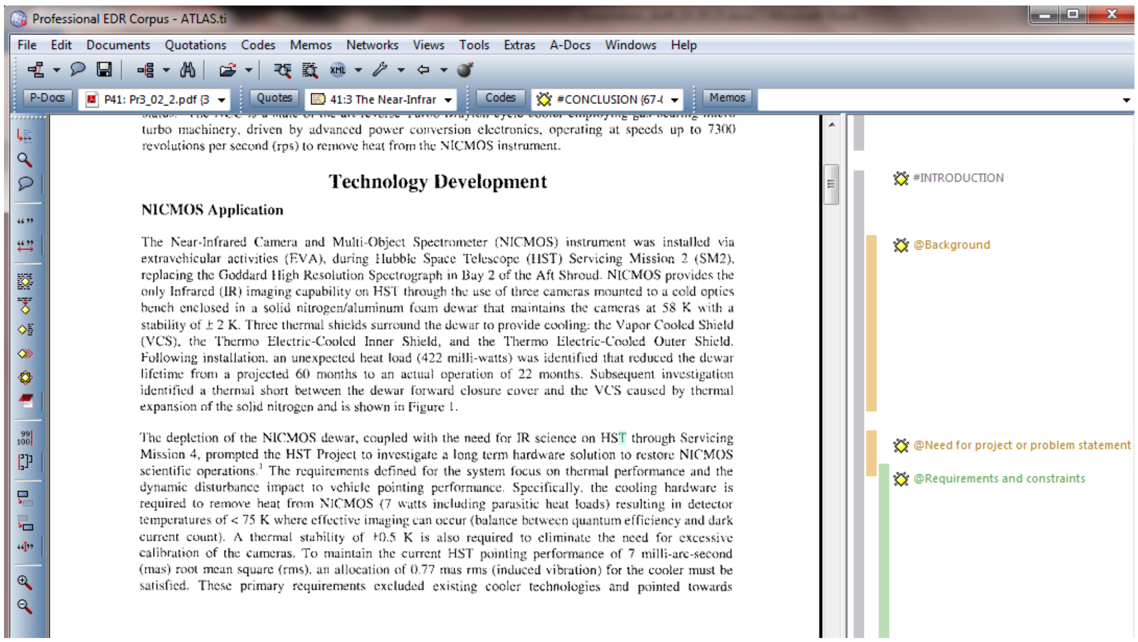


Figure 5.1 Atlas.ti 6.2 screenshot

Atlas.ti was selected for the study after a review of exiting QDA programs at the website of the Computer Assisted Qualitative Data AnalysiS (CAQDAS) Networking Project (at http://www.surrey.ac.uk/sociology/research/researchcentres/caqdas/), which provides practical support, training, and information in the use of a range of software programs designed to assist qualitative data analysis. Initially, NVivo 9 was also selected as a potential QDA program that could be used in the present study. However, after pilot coding of an EDR sample with demo versions of Atlas.ti 6.2 and NVivo 9, Atlas.ti was chosen for the present genre analysis. This decision was made based on several factors, such as the program's ease of use, its handling of .pdf and .doc formats, and its price.

After Atlas.ti 6.2 was selected for the study, it was used by the two collaborating coders to code organizational units and moves in all professional EDRs. After all individual coding assignments were completed and possible coding ambiguities and other concerns discussed at follow-up sessions, the researcher input the coding outcomes into a separate Atlas.ti file that was used for compilation of unit-based corpora for their subsequent linguistic analysis.

5.3.2.4. Coder Training

To achieve more consistent coding, coder training was provided. Figure 5.2 shows schematically the major stages of the coder training and individual coding sessions that followed them. To train the coders to code professional EDRs, the researcher created a tutorial disc, with step-by-step instructions. Because a QDA program Atlas.ti was used for coding, the tutorial disc also included instructions on how to use the program and several how-to video clips. In addition, the tutorial disc contained three professional EDRs for practice coding, with one of the EDRs having been coded already by the researcher. After the coders studied the tutorial materials and coded the two practice EDRs, the two coders and the researcher met for the coder training session. The training session was audio recorded to allow the researcher to listen to it multiple times and reflect on particular issues that arose during coding discussions. Additional meetings of the researcher with each individual coder followed the training session and are discussed in Section 5.3.2.5.

During the coder training session which lasted 1.5 hours, the coders asked questions about the Atlas.ti program used for coding and the coding scheme itself and compared their coding of the two practice EDRs. While substantial agreement was reached on the identification of major EDR organizational units, several problems surfaced because the coders felt that specific moves could be interpreted differently when using the coding scheme. For instance, Testing and Analysis Results move from the initial coding scheme was changed into three separate moves: Testing Equipment, Testing Procedures, and Results. Each of these moves serves a different communicative purpose and uses different types of linguistic devices to do so. Ambiguous coding categories, such as the original Testing and Analysis Results move, were thoroughly discussed by the two coders and the researcher, and necessary clarifications and examples were added to the scheme. Then the ambiguous moves were re-coded with the improved coding scheme by all participants of the coding session. Following the training session, each coder was assigned three different sets of eight professional EDRs (i.e., 24 EDRs per coder) to be coded in Atlas.ti by using the modified coding scheme. The researcher coded all 48 reports assigned to both coders. The procedures for individual coding sessions with each coder are described in Section 5.3.2.5.

Following the suggestions of Biber et al. (2007), the researcher coded all practice EDRs by hand. Biber et al. urge researchers carrying out genre analyses to complete pilot coding by hand because “coders are seeking to understand the functional-semantic purposes of text segments” (p. 33). Through this process, discrepancies can be identified and discussed, leading to increased inter-rater reliability among coders and a more usable analytical framework for the genre analysis. The coders, however, coded all practice EDRs electronically with Atlas.ti. Coders were asked to use Atlas.ti as a means to familiarize themselves with the program that was to be used for independent coding in the study.

Stage I: Tutorial disc with Atlas.ti, coding scheme, and three sample professional EDRs was created and distributed to the two coders.

↓

Stage II: Coder training session. The researcher and the two coders compared the coding results of sample EDRs, discussed ambiguous coding categories, and made necessary changes in the initial coding scheme.

↓

Stage III: Professional EDR individual coding sessions. The two coders were asked to read and code 24 professional EDRs each. To compare coding of these EDRs, each coder met with the researcher individually after each set of 8 reports was coded. Thus, the researcher met with the two coders six times, three times with each coder.

↓

Stage IV: Remaining professional EDR individual coding sessions. One of the coders was asked to read and code the remaining 26 professional EDRs. To compare coding of these EDRs, the coder met with the researcher individually after each set of 8-9 reports was coded. Thus, the researcher met with the coder four times.

↓

Stage V: Follow-up on the individual coding sessions. The researcher listened to the audio-recorded individual coding sessions multiple times and reviewed the notes taken during these sessions. All unresolved questions and concerns were then recorded and addressed with each coder individually during the follow-up sessions. Necessary modifications to the EDR coding were made based on the outcomes of these follow-up sessions.

Figure 5.2 Major stages of the coder training and individual coding sessions

5.3.2.5. Independent Coding

After the training session, coding assignments were provided to the two coders for individual coding. Then, each coder met with the researcher individually to compare coding one or two times per week, depending on the coder's availability. One set of previously coded EDRs (7–8 EDRs per set) was reviewed at each individual coding session. During each session, the coder and the researcher compared the results of their individual coding and raised questions about the segments of text that were difficult for unit or move identification. These difficult segments were then discussed until consensus was reached. Based on these discussions, necessary modifications were made and clarifications were added to the coding scheme. For example, the Potential Problems move was added to the coding scheme after it was realized that professional EDR writers sometimes address problems that might have or may hypothetically occur rather than problems that were encountered in the design process but. These changes were then promptly communicated to the second coder who was not present at a particular individual coding session.

Each individual coding session was audio recorded, and notes were taken both during the session and after the session while listening to session discussions again. After the results of coding for each set of EDRs were compared and discussed, the researcher listened to the session's audio recording, read her notes taken during the session, and recorded any smaller issues that might not have been resolved. These minor issues (e.g., changing the longer move label Problem Statement or Need for Project to shorter and more fitting label Need for Project), which otherwise could have gone unnoticed, were thus addressed during the follow-up individual meetings with each coder. One follow-up meeting typically happened after each individual session, unless there were no unresolved minor issues found in the session notes and audio recording. Both coders coded EDRs by using Atlas.ti whereas the researcher hand coded all reports. Subsequently, after work with coders was completed and all coding issues resolved, the researcher input the coding results into Atlas.ti for subsequent genre and corpus-based linguistic analyses.

5.3.2.6. Validation of the Framework and Procedures for Move Analysis

Because genre analysis involves individual cognitive judgments for the identification and coding of the discourse components of a text, it was necessary for this analysis to be based on a detailed coding scheme that explicitly and unambiguously defines units and moves of EDRs. In addition, this scheme needed to be evaluated to determine that independent coders could achieve relatively high levels of agreement when using it for coding. Thus, the next important step involved validating the developed coding scheme and establishing its reliability. The scheme's validity was established by discussing its components with engineering professionals who are familiar with design reports, and frequently read and/or write them. The present research then strived to establish the scheme's reliability by involving two engineering expert coders, who were carefully selected and trained to use the coding scheme for independent coding. Unlike some studies that establish reliability of the coding scheme by comparing coding results for a small subset of texts, in the present study the entire professional EDR corpus was coded by at least the researcher and another expert coder. Finally, in an effort to further establish reliability of move coding, the study included individual follow-up sessions with both coders; these sessions were intended to resolve any encountered coding issues.

CHAPTER 6. THE LINGUISTIC CHARACTERISTICS OF STUDENT AND PROFESSIONAL ENGINEERING DESIGN REPORTS

6.1. Introduction

Chapter 3 reported results of the situational analysis of student and professional EDRs with the developed EDR framework. This chapter further investigates differences and similarities between these two EDR registers by examining the lexical and syntactic characteristics of the EDRs written in professional and academic settings. The chapter begins with a brief overview of previous research on linguistic variation in disciplinary writing, focusing especially on studies examining discourse in engineering. The results of the analysis of linguistic variation in EDRs and functional interpretations of the discovered similarities and differences conclude the chapter.

6.2. Research on Grammatical Variation in Academic and Professional Writing

Numerous studies of academic and professional discourse have been carried out in the last two decades. Most of this research has focused on written academic registers, most notably on research article (RA) in a variety of disciplines (Chang & Kuo, 2011; Chen & Ge, 2007; Cortes, 2004; Gosden, 1992; Henderson & Barr, 2010; Hyland, 2007a; Reimerink, 2006; Salager-Meyer, 1994). The main rationale for these descriptive studies of linguistic characteristics is the belief that knowledge and practices of particular academic and professional communities are reflected within the language being analyzed. Consequently, much of this research has been motivated by the need to prepare students to produce registers they need in schools and universities as well as later in their careers outside the classroom.

Naturally, research in this vein generated studies (a) examining professional and academic writing for pedagogical purposes (Shi & Kubota, 2007; Stotesbury, 2006; Ward, 2007, 2009), (b) comparing professional and student writing (Flowerdew, 2004, 2008; Henderson & Barr, 2010; Koutsantony, 2006; Shaw, 2006), and (c) comparing academic registers written by native speakers of English and those produced by non-native speakers (Pérez-Llantada, 2010; Vold, 2006; Wenyan, 2008).

Within this body of descriptive research of the linguistic variation in disciplinary writing, the vast majority of studies compare either (a) the same register across several disciplines (Charles, 2006; Hyland, 2008; Vold, 2006) or (b) two registers within a discipline or disciplines (Flowerdew, 1993; Koutsantony, 2006). Although the RA has been by far the most researched register, other academic written registers have also been examined, including PhD theses and dissertations (Charles, 2006; Hewings & Hewings, 2002; Koutsantony, 2006), textbooks (Conrad, 2001; Chung & Nation, 2003, 2004; Mudraya, 2006; Ward, 2007, 2009), recommendation reports (Flowerdew, 2004; 2008), and book reviews (Tse & Hyland, 2006). Studies of linguistic variation in disciplinary writing have also examined linguistic features within particular sections of target registers, with the RA as the most commonly examined genre. For example, this line of research investigated RA abstracts (Pho, 2008; Promsin, 2006; Salager-Meyer, 1992), RA introductions (Kanoksilapatham, 2012; Samraj, 2002), and RA methods (Bruce, 2008).

Studies of linguistic variation in disciplinary writing have examined a range of lexico-grammatical features characteristic of particular registers, including stance (Charles, 2003; Hyland, 1998; Salager-Meyer, 1994), *that* complement clauses (Charles, 2006), imperatives (Swales, Ahmad, Chang, Chavez, Dressen, & Seymour, 1998), reporting verbs (Bloch, 2010), and personal pronouns (Harwood, 2005; Kuo, 1999; Luzón, 2009). Other studies have examined complex types of noun phrase structures, the defining characteristic of academic prose (Biber, 1988; Biber & Clark, 2002; Biber & Gray, 2010; Varantola, 1983). This line of research has (a) documented the nominal style of academic writing and linguistic features typically associated with it and (b) connected this nominal style to the informational purpose and audience of academic writing. For example, Biber and Gray (2010) contrasted the reliance of academic registers on noun phrase structures with the reliance of conversation on the use of verbs and clausal structures. This research identified nouns and phrasal modifiers (e.g., nouns as nominal premodifiers, attributive adjectives, and prepositional phrases as postmodifiers) as ubiquitous features of academic writing. Diachronically, Biber and Clark (2002) investigated the shift in modification patterns with complex noun phrases, concluding that the shift to the nominal style in present day academic prose contributes to the development of a much more compressed style of writing.

One of the most comprehensive studies of lexico-grammatical features in English is *The Longman Grammar of Spoken and Written English* (LGSWE) (Biber et al., 1999). The corpus-based LGSWE shows the distributional data of lexico-grammatical features of written and spoken registers in British and American English, comparing academic prose, conversation, fiction, and newspaper writing. Findings about academic prose represented in the LGSWE are book extracts and research articles from 13 academic disciplines, including engineering/technology. In fact, the present study uses many of the LGSWE's findings about the lexico-grammatical features of academic prose to compare their patterns of use to the ways these features are used in student and professional EDRs.

As this section's brief overview demonstrates, a range of linguistic features has been examined in a variety of disciplines. Moreover, even the notion of discipline has been approached with a differing degree of specificity across studies. At a more general level, researchers have compared disciplines grouped together along two parameters: hard versus soft fields and pure versus applied fields. Other studies have investigated the language of groups of disciplines representing particular types of disciplines, such as physical sciences and social sciences (e.g., Bruce's 2008 study of linguistic features of RA methods sections in biology, organic chemistry, medicine, chemical engineering and in applied linguistics, education, sociology, and psychology), or science (Kuo's 1999 study of personal pronouns in physics, computer science, and electronic engineering). Finally, most studies have focused on analyses of linguistic variation within particular disciplines, including business (Hewings & Hewings, 2002), linguistics (Lee & Chen, 2009), medicine (Salager-Meyer, 1994), and biology (Hyland, 1996).

Linguistic variation in engineering registers has been examined as part of large and small-scale research across many disciplines (Aktas & Cortes, 2008; Hyland, 2001, 2002, 2007a, 2008; Shaw, 2006; Swales, 1998). However, there are only a few corpus-based investigations into only engineering written discourse. Table 6.1 presents a brief summary of studies examining lexical and grammatical features in engineering writing. As can be seen, studies investigating particular grammatical features are rare and include research on hedging devices, nominal structures, infinitive clauses, and the pronoun *we*. Importantly, this small body of research mainly focuses on student writing, often produced by L2 engineering students, and hardly includes comparative analyses of student and professional engineering written discourse.

In a small corpus of 40 engineering abstracts from research theses written in English by Thai students, Promsin (2006) examined abstracts' rhetorical moves and the use of hedging devices consisting of modal and reporting verbs. The author's findings indicate that Thai students predominantly use the modal verb *can* to express possibility and the degree of certainty in the abstracts' results move. Other modal verbs investigated in this study (e.g., *may*, *should*, *must*) were found to be used extremely rarely. The study also reported a high rate of occurrence of the reporting verb *show*, which occurred far more often than other verbs examined, such as *offer*, *introduce*, *indicate*, and *propose*.

Koutsantoni (2006) also investigated hedges in engineering writing, comparing rhetorical strategies used by authors of 17 engineering RAs and nine research theses. This research focused on discourse-based strategic hedges (Hyland, 1996, 1998) and their personal or impersonal expression. Koutsantoni (2006) used a small corpus that was not electronic, so all linguistic features were manually counted. The results of the study showed differences in the density and function of hedges in the two registers, indicating that student writers hedge more frequently than do professional RA authors. Students also tend to avoid taking personal responsibility for their claims, distancing themselves from their claims by being impersonal. Conversely, expert writers frequently use personally attributed hedges both to weaken their claims by making them sound like personal evaluations, and to diffuse responsibility for a claim by making it seem collective.

In a small exploratory study, Dalton (2008) used a corpus of 11 memo reports produced by L2 engineering students to examine this register's organizational elements and linguistic features. To describe salient features that contribute to the document's level of success, or readability, as judged by the engineering teacher, the texts were examined in terms of their use of noun phrases and infinitive clauses. Five reports were used in the analysis of noun phrases and the remaining six for the investigation of infinitive clauses. The results of the analysis suggest that more successful writers not only produced overall longer reports, but also used noun phrases more frequently, used noun phrases with greater number of words in them, and used noun phrases which were better formed overall. These writers also used a substantially wider range of verbs in infinitive clauses and used these clauses effectively in terms of their quality, accuracy, and appropriateness.

Luzón (2009) also examined the writing of L2 engineering students. Her study analyzed the discourse functions of the pronoun *we* in a corpus of 55 L2 student multi-authored engineering research reports. The results of her analysis show that engineering L2 students use the pronoun *we* much more frequently than do expert RA writers, which echoes previous research findings regarding the higher visibility of the author and the higher use of spoken language features in L2 students' writing. The results of the study also suggest that L2 engineering students lack an understanding of ways in which expert writers use *we* to construct their authorial identities as members of the community.

Table 6.1 demonstrates that (a) relatively few studies examine only engineering registers and (b) most studies focusing on engineering registers explore engineering vocabulary. Further, in this body of research, student-produced registers are seldom compared to those produced by practicing engineers. In fact, only Flowerdew (2004, 2008) and Koutsantoni (2006) compare registers produced by professional engineers to those produced by L2 students, both undergraduates and advanced graduate students. Finally, there are virtually no large-scale, detailed studies of a specific engineering genre.

Table 6.1 Summary of studies investigating language use in engineering registers

Study	Discipline	Registers compared	Linguistic features
Dalton (2008)	chemical engineering	L2 student memo reports	noun phrases, infinitive clauses
Flowerdew (2004)	environmental engineering	L2 student and L2 professional recommendation reports	key words of problem-solution pattern
Flowerdew (2008)	environmental engineering	L2 student and L2 professional recommendation reports	key words of problem-solution pattern
Koutsantoni (2004)	electrical engineering	research articles	appraisal
Koutsantoni (2006)	electronic and chemical engineering	research articles and student theses	hedging devices
Luzón (2009)	computer engineering, industrial engineering, chemical engineering	L2 student research reports	pronoun 'we'
McKenna (1997)	structural, environmental, and communications engineering	engineering reports	grammatical subject position, theme of the sentence
Mudraya (2006)	basic engineering disciplines	textbooks	vocabulary, collocations
Promsin (2006)	electrical engineering	abstracts of L2 students' research theses	hedging devices
Ward (2007)	chemical, civil, electrical, industrial, mechanical engineering	undergraduate textbooks	collocations
Ward (2009)	5 engineering disciplines (see Ward, 2007)	passages from textbooks	vocabulary

It can also be seen that corpus-based studies of engineering writing focus on such registers as textbooks, research articles, research theses, and engineering reports of different types. The examined engineering reports include L2 student memo reports (Dalton, 2008), L2 student and L2 professional recommendation reports (Flowerdew, 2003, 2008), L2 student research reports (Luzón, 2009), and professional engineering reports (McKenna, 1997). Of these studies, only McKenna (1997) investigated L1 engineering reports, but his research was based on the analysis of only three reports from three engineering disciplines. It is also not entirely clear what specific kind(s) of engineering reports were examined in this study. Finally, the study did not provide survey of a wide range of linguistic features, focusing instead on grammatical subject position, and theme of the sentences. Thus, little knowledge currently exists about variation in the general grammatical characteristics of specific types of engineering reports, such as engineering design reports (EDRs), written in academic and professional settings.

This dissertation research addresses this gap by examining lexico-grammatical features that were shown to vary across student and professional engineering written registers as well as between student and professional EDRs in an exploratory pilot study (Poltavtchenko, 2009). These features include major content classes (i.e., nouns, verbs, adjectives, and adverbs), lexical classes of nouns and verbs, personal pronouns, passive voice, and modals. The study also examines features that have been associated with grammatical complexity, including vocabulary size (operationalized as type/token ratio), average word length, nominalizations, prepositions, conjunctions and coordinators, and complement clauses. The frequency distributions of the selected lexico-grammatical features across the two EDR registers are described in Sections 6.3.1 – 6.3.6 . Section

6.3.7 then reports on the distribution of the collective features of grammatical complexity across EDR registers.

6.3. Analysis of Selected Lexico-Grammatical Features of EDRs

The primary goal of this chapter is to provide a relatively comprehensive linguistic description of EDRs written in upper-division university engineering courses and in the workplace. Therefore, the descriptions are based on a range of linguistic features, including major content classes (i.e., nouns, verbs, adjectives, and adverbs), lexical classes of nouns and verbs, personal pronouns, passive voice, and modals. The linguistic analysis follows procedures described in Section 5.2. Table 5.1 shows features examined in the present study and provides examples. The following sub-sections report the frequency distribution of these selected lexico-grammatical features across the two EDR registers.

6.3.1 Distribution of the Content Word Classes

Previous research on academic writing has reported distributions of the four major content classes for the overall register of academic writing (Biber et al., 1999), for a number of written and spoken university registers (Biber, 2006a), and for research articles in a variety of academic disciplines (Gray, 2011). Patterns similar to distributions of the content classes in academic writing have been observed in the present study of EDRs. Figure 6.1 shows that nouns are by far the most frequently used part of speech in both student and professional EDRs, occurring more than twice as frequently as any other content word class. Adjectives are used more frequently than adverbs in both EDR registers. Also, in both EDRs registers, adjectives are used slightly less frequently than verbs, though professional EDR writers rely on adjectives to a greater extent than do engineering students.

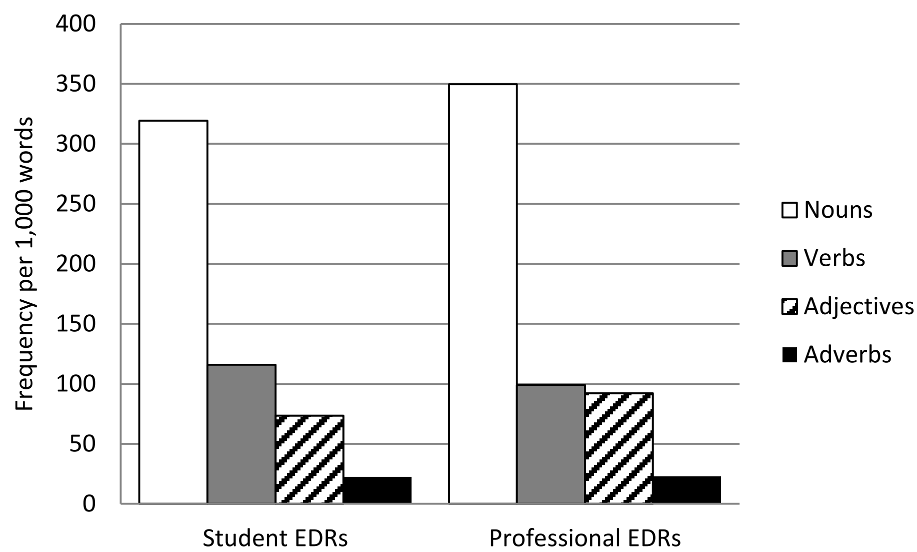


Figure 6.1 Distribution of nouns, verbs, adjectives and adverbs in EDRs

In fact, professional engineers use both nouns and adjectives significantly more frequently per 1,000 words than do engineering students (see Table J1 in Appendix J for results of significance tests). On the other hand, student writing relies significantly more on the use of verbs as compared to writing produced by practicing engineers. There was no significant difference in the rates of occurrence of adverbs in student and professional EDRs.

Text excerpt 6.1 from a student EDR illustrates the high use of nouns and adjectives, but also a higher reliance on verbs of writers in academic settings. This sentence of 25 words consists of 6 nouns (**bolded**), 2 adjectives (*italicized*), 4 verbs (underlined).

6.1 [**Name**], who is the **group leader**, developed an *initial* **design** during the **summer** of 2002 when it was first discovered that there was *inadequate* **mixing**. (St6_03_5)

Text excerpt 6.2, conversely, exemplifies the much higher use of nouns and adjectives in professional EDRs. The excerpt sentence contains 36 words, of which 14 are nouns (**bolded**), 2 are adjectives (*italicized*), and 1 is a verb (underlined).

6.2 The **cryocooler** was then integrated with its **support structure**, **power** and **control electronics**, **instrumentation**, and **heat rejection system** over the *next several* **months** in **preparation** for the **HOST mission** (Pr2_02_2).

Because both EDR registers represent disciplinary writing, these general patterns of distribution of the content word classes were expected. The greater rates of occurrence of nouns and adjectives in professional writing corroborate the results of previous research on disciplinary writing as these features are generally associated with the information-packed style of academic and professional writing. The findings of the present study are also consistent with the results of the exploratory pilot study (Poltavtchenko, 2009), indicating a higher reliance of student writers on verbs, which is more characteristic of spoken rather than written registers. These results suggest that the most prominent differences between student and professional EDRs seem to be related to the distribution of nouns and verbs; thus, Sections 6.3.2 and 6.3.4 will further explore variation in content classes of nouns and verbs by examining their semantic classes.

6.3.2 Nouns

Figure 6.2 shows the breakdown of nouns across semantic domains. As can be seen, many of the common nouns in EDRs refer to abstract concepts and processes (e.g., *cause, choice, criteria, quality*). Interestingly, despite the higher overall rate of use of nouns by professional engineers writing EDRs, the abstract nouns were found to be used slightly more frequently by student writers. Overall, the patterns of noun use by professional and student writers look very similar.

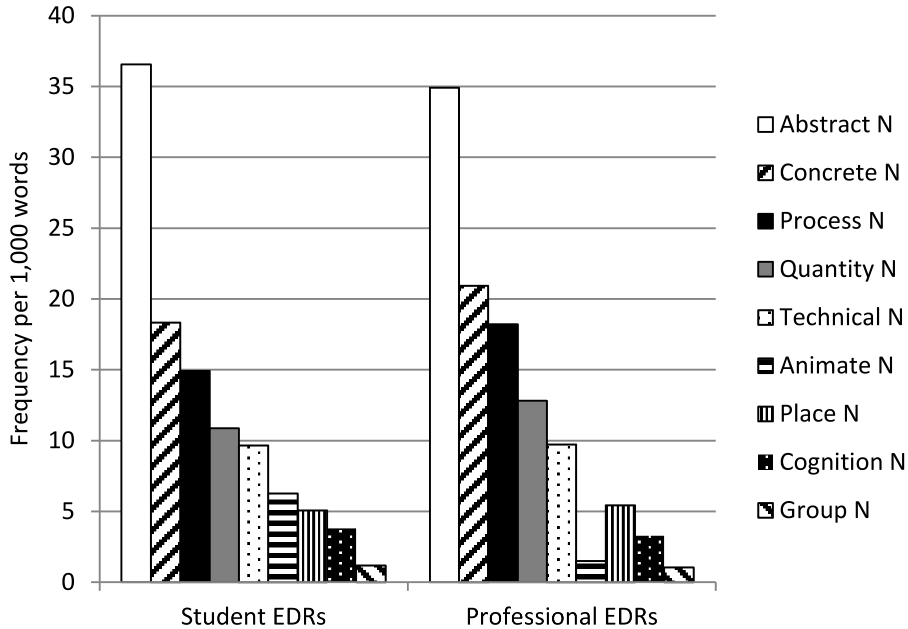


Figure 6.2 Distribution of nouns across EDR registers

Because overall nouns are used more frequently in professional EDRs, it was expected that most semantic classes of nouns would be used more frequently by practicing engineers. Figure 6.2 shows that, indeed, only three classes of nouns (cognition, animate and group nouns) are used with the same or higher frequency by engineering student writers. All other classes of nouns are used more frequently in professional EDRs, with significant differences found in the use of process nouns. Despite these differences, overall patterns of distribution of different semantic classes of nouns in the two EDR registers look surprisingly similar.

In both EDR registers, the findings demonstrate the prevalent use of abstract nouns (e.g., *account, background, characteristic, relationship, resource*), followed by the use of concrete (e.g., *drawing, manual, object, screen, steel*), process (e.g., *application, development, experiment*), quantity (e.g., *frequency, measure, number, percent, temperature*), and technical nouns (e.g., *component, diagram, equation, software*). Other types of nouns, such as place (e.g., *area, building, city, forest, shop*), cognition (e.g., *analysis, assumption, decision, idea, reason*), and group nouns (e.g., *company, institute, university*) are used much less frequently in both student and professional EDRs. Interestingly, student writers of EDRs use cognition and group nouns slightly more frequently than practicing engineers. These results could be attributed to the fact that students are often required to explicitly justify their design decisions, leading these writers to frequently rely in their descriptions on such nouns as *reason*, *decision*, and *evaluation*. Students also tend to refer to their teams, faculty advisers, and home institutions, which is a likely contributing factor for a slightly higher occurrence of group nouns in student EDRs.

The reliance of both EDR registers on abstract and process nouns, describing intangible, abstract concepts and processes, has been previously observed in engineering registers and registers in hard sciences (Biber, 2006a; Gray, 2011). Excerpts 6.3 and 6.4 show the high occurrence of abstract (<u>underlined</u>) and process (**bolded**) nouns in professional EDRs.

6.3 These **fabrication** <u>methods</u>, including high-<u>speed</u> **machining**, **photolithography**, and **micro-molding**, encompass <u>feature</u> **production** from the nanometer to millimeter scales and were synergistic with thermal **management research** (J. Klausner), impedance **spectroscopy characterization** of fuel cell **performance** (M. Orazem), and computational fluid <u>dynamics</u> **modeling** work by enabling new geometries to be realized and studied. (Pr3_08_5)

6.4 Other <u>program</u> **activities** include the **development** of **automation** for solar cell string **inspections**, string **busing**, materials **lay-up**, and **lamination**; **enhancements** to the **lamination process**; and **performance testing** of large area <u>modules</u>. (Pr4_05_2)

Previous research also pointed out the focus of engineering discourse on everyday common entities, events, and processes described in terms of technical concepts and principles (Biber, 2006a; McKenna, 1997; Ward, 2007). In fact, McKenna (1997) suggests that converting common entities into scientific concepts helps engineers to differentiate themselves from people outside their professional community. This pattern was observed in both student and professional EDRs, whose writers combine frequent use of both abstract and process nouns with the use of concrete nouns, especially when providing background information. Excerpt 6.5 shows how professional engineers provide background information on Mosul Dam and the site geology, thus generating the need for the design project, the development of the geologic conceptual model of the dam. The excerpt illustrates how an ordinary object in the form of a concrete noun (i.e., the dam) is being defined and described by using numerous abstract and process nouns. Concrete nouns are **bolded**; abstract and process nouns are underlined.

> 6.5 Mosul **Dam** (formerly known as Saddam **Dam**) was constructed in the 1980s on the Tigris River near the city of Mosul, Iraq, for irrigation, flood control, water supply, and hydropower. The **site** was chosen for reasons other than geologic or engineering merit. … Specifically, the **dam** was constructed on alternating and highly variable units of gypsum, anhydrite, marl, and limestone, each of which is soluble in **water** under certain conditions. Impoundment of a large freshwater reservoir in contact with these unstable geologic materials promotes continuous dissolution in the foundation and abutments, with preferential and rapid dissolution of gypsum and anhydrite **layers**. This condition creates a situation demanding extraordinary engineering measures to maintain the structural integrity and operating capability of the **dam**. (Pr5_07_1)

Interestingly, the class of nouns that student writers use significantly more frequently than do professional engineers is animate nouns (e.g., *client, consumer, owner, professor, student, user*). This extremely high rate of use of animate nouns in student EDRs can be explained by more detailed descriptions of the product end users and commonly required sections describing involvement of student team members in the project. Additionally, student design projects often revolve around university life: courses, students, and faculty. Excerpts 6.6–6.9 illustrate the use of animate nouns (**bolded**) by engineering students in the description of the (a) design end users (6.6–6.7) and (b) team members' involvement in the project (6.8–6.9).

6.6 The end product design of this project is a tool to facilitate the **administrator** in [name] department in the process of assigning courses to **faculty members** and teaching **assistants**. The tool, referred by DRAT, is password oriented in a way to provide access security for both the **administrator** and the **users**, and shall be accessible from anywhere through any standard web-browsers. (St2_02_13)

6.7 This module has several different applications and could be used by many **people**. Some possible **users** are **paramedics**, **lifeguards**, or even **teachers**. It should be able to be used by high school **students** or any **adult** with a high school education. A **user** will need to have some knowledge of how to use a computer and operate a PDA. (St2_05_4)

6.8 As the team worked through the design process, it was crucial to collaborate closely with our **client**, [**name**]. It was important to continually consult with and inform the **client** of the status of this project. The team was always able to contact [**name**] through e-mail or in person. The team **leader** for this project, [**name**], had the luxury of working with [**name**] and was able to give him constant updates on the project as well as gather pertinent information and feedback as needed. The team also developed several community partnerships. [**Name**], a local **writer** and **historian**, partnered with the team to add an educational and aesthetic dimension to the trail. [**Name**], the Environmental Code **Specialist** and [**name**], the Environmental Program **Assistant**, also made a great contribution to the team's design process. (St2_02_13)

6.9 Overall, the effort required for the project was less than expected because the design and its implementation turned out to be simplistic but functional, which is what the **client** desired. Differences between each team **member**'s efforts were because the team decided to utilize the abilities of the **individuals** with the best skills for each task. For example, **user** documentation was worked on more heavily by the **individuals** who had previous experience developing similar documents. (St2_06_18)

Overall, the patterns of distribution of nouns indicate that students rely on nouns in general, and on most semantic classes of nouns in particular, to a lesser degree than do practicing engineers. At the same time, student writing shows much higher rates of occurrence of verbs typically associated with less information-packed registers. To investigate this finding further, the next subsection explores the distribution of pronouns, function words that are also typically associated with more conversation-like registers and whose distribution patterns are generally linked to the distribution of verbs.

6.3.3 Pronouns

Both spoken and written academic registers are generally characterized by their reliance on nouns to a greater extent than on pronouns (Biber, 2006a; Biber et al., 1999), but academic written registers use pronouns much less frequently compared to spoken language. Despite their relatively infrequent use in academic and professional writing, personal pronouns perform a variety of discourse functions, as pointed out by a number of corpus-based studies (Flottum, Kinn, & Dahl, 2006; Harwood 2005; Hyland, 2001, 2002; Kuo, 1999; Luzón, 2009; Martínez, 2005).

Figure 6.3 shows that although overall patterns of use of personal pronouns in the two EDR registers look very similar, student EDR writers seem to rely on the use of personal pronouns to a much greater extent than do practicing engineers in the workplace. First person pronouns are the most frequent type of personal pronouns used in EDRs written in both settings, followed by third person pronouns, and second person pronouns. Because all EDRs collected for the study were multi-authored, all first person pronouns were observed in plural form *we*.

Previous research has identified a variety of functions that first person pronouns fulfill in academic writing, including stating a purpose or goal, making the text structure clearer to the reader, stating hypotheses, explaining experimental procedures, showing results or findings, expressing personal opinions, and constructing the author's identity as a member of the discourse community. Indeed, comparing the use of first person pronouns in student and professional EDRs reveals that variation exists not only in their frequency of use but also in terms of the functions these pronouns perform.

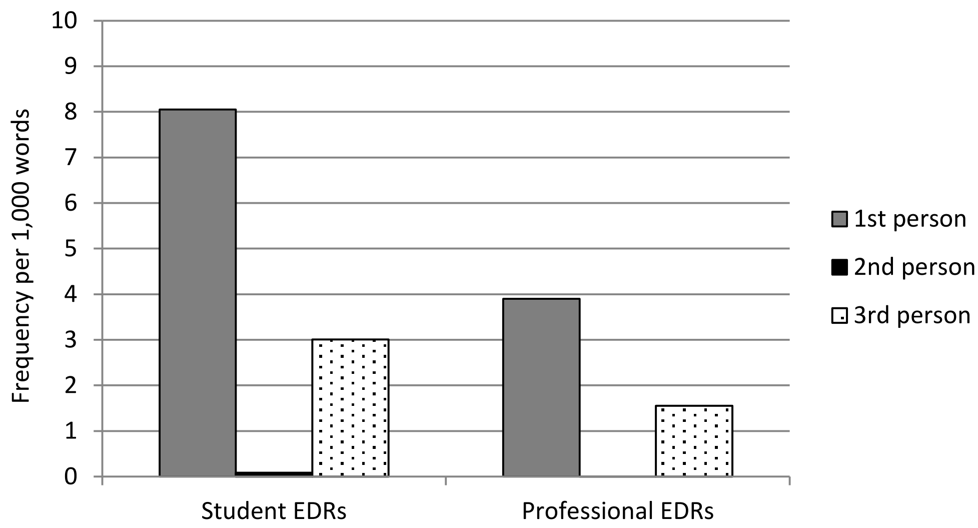


Figure 6.3 Distribution of personal pronouns across EDR registers

The most common purposes for the use of *we* in student EDRs appear to be those of explaining experimental procedures and of showing results or findings. Excerpt 6.10 illustrates how students frequently refer to themselves in the process of testing their design. Excerpt 6.11 demonstrates the use of *we* to report on the team's accomplishments and express a personal opinion about the project's success.

6.10 **We** tested our basic mechanical design by writing a line following program using a bang-bang algorithm. Our robot easily followed the black line but **we** discovered that the Lego light sensors that **we** were using did not return the linear response that **we** would need to implement a PD control algorithm. To address this problem **we** located and tested some high sensitivity infrared electro-optic proximity sensors. These sensors gave us the linear response that **we** needed and additionally had a wider range of response with less noise than the original Lego light sensors. (St6_03_10)

6.11 Not only did **we** complete our primary objective, but **we** also had a very victorious performance both at the [University] runoff and at the … Robotics Competition in [place]. **We** won third and sixth place respectively. **We** feel we represented the [University] extremely well at the conference. … In the end, **we** accomplished each goal that was defined and completed our project on schedule. (St6_04_23)

While professional EDR writers also use *we* to report on design procedures and results, the results of the analysis suggest that these writers refer to themselves not as often as do students. In fact, in professional EDRs, it is rather uncommon to find such a high concentration of first person pronouns as shown in student examples above. Instead of mentioning themselves and their actions repeatedly, practicing engineers seem to provide much more detail on their activities and/or shift the reader's attention to specific details about materials and instrumentation used for these activities.

6.12 At that time, **we** invented a unique soldering tip that operates at a constant temperature and has a built-in pin that holds the joint in contact until the solder freezes. The soldering tip, shown in Figure 49, is heated by a small cartridge heater and its temperature is monitored by a thermocouple. The heated tip and the cooling pin are spring loaded for compliance with the soldered parts. (Pr4_05_2)

6.13 In order to develop a good understanding of the system and a useful analytical tool, **we** modeled the system both with a mathematical model and with an equivalent circuit. Both models reflect the mutual coupling between drivers and metallic objects, and include the first stage of analog processing. (Pr1_05_3)

6.14 The physical model provided WSE data with the ICS for many different ice-jam conditions. **We** selected three data sets (2000, 6000, and 6100 cfs) that offered fairly long, steady-state ice jams upstream of the ICS. As with all the tests, however, the jams were grounded at the ICS, a feature that cannot be modeled directly with HEC-RAS. Instead, **we** matched the measured WSE's by setting 6-ft-thick ice covers along the first 50 ft upstream of the ICS (Fig. 19). **We** selected a conservative value of 0.08 for Manning's n of the underside of the ice jam and used this for all the final ice-jam runs. Runs conducted with variable Manning's n (i.e., n dependent on jam thickness) yielded similar results. Also, runs with the ice jam toe at Mill Road converge. (Pr5_00_1)

Professional engineers also use *we* to orient readers by stating their goals (6.15) and explaining the structure of the report (6.16–6.17).

6.15 **We** now turn our attention to proving the passivity of the robot manipulator. (Pr2_04_2)

6.16 In this subsection **we** describe the primary user interfaces involved in Grey at the time of this writing. (Pr2_05_4)

6.17 **We** begin by discussing these strategies and how they have defined our design. **We** then present the design and analysis of a small-scale prototype water treatment system (10-litre per hour) that was constructed and tested in Bangladesh in Summer 2008, and a 100-litre per hour prototype system that is currently undergoing testing in Bangladesh. **We** detail our cost analysis and discuss a possible implementation model that could provide sustainable water treatment services to rural Bangladeshis. **We** conclude with lessons learned. (Pr1_09_3)

Third person pronouns are also much more common in student EDRs. Student EDR writers frequently use third person pronouns to refer to clients and sponsors of their design projects (6.18–6.20), their team members (6.21–6.22), and users of the design projects (6.23–6.27). Surprisingly, although students typically refer to hypothetical users as males by using *he* (6.23–6.24), they do use inclusive pronouns *he or she* (*he/she*) (6.25–6.26), and one student report only used *she* to refer to all hypothetical users (6.27).

6.18 The adaptor circuit was then constructed on the prototyping board in order to take measurements as well as to demonstrate the functionality of the circuit to the sponsor. Although **he** felt that it provided sufficient illumination in contrast to the halogen bulb, it was not as bright as **he** expected. (St6_04_15)

6.19 The information was relayed to our client, Dr. [Name], to determine which type of application of the hydrogen **he** would like to use.(St3_03_2)

6.20 It should be noted there was a design change at this juncture when the client requested we use Lithium batteries **he** already owned, rather than purchase AGMs. (St3_10_17)

6.21 We then divided these responsibilities amongst our team members in terms of skill and interest. [Name] and [Name] had the responsibility to evaluate the proximity/infrared sensors, interface them with the micro-controller, and create certain sub-routines for its proper utilization by the micro-controller. After **they** finish this aspect of the project, **they** must then create a viable feedback system, which utilizes both the guidance and propulsion systems. [Name] had the responsibility to create the overall chassis specific to the needs of the project and limitations posed by the air-bearing pad. **He** was also responsible to develop the propulsion system for the robot, and construct the perimeter for the air-bearing surface. (St6_04_26)

6.22 Next using available materials, [Name] welded the tubes that connect the compressor and the coils. **He** also welded a view glass on the condenser side of the system. (St6_04_19)

6.23 In addition to Fk, we determine the distance that the user travels as if **he** is pedaling an actual bicycle. (St6_04_7)

6.24 We used those orthogonal spreading codes to encode the data bits of the users. If a specific user send a 1, his spreading code remains the same. If **he** sends a 0, the spreading code is inverted. (St6_05_13)

6.25 All parameters that vary significantly over the Springfield Township are stored in the global data layer and are accessed by the user when **he/she** specifies the watershed to be analyzed. (St4_05_8)

6.26 When shooting a rifle at long distances the bullet will drop significantly. A shooter currently has several options for accommodating for drop. **He or she** can guess the amount of drop and aim the gun over the target. (St2_2_20)

6.27 A problem with the standard design is that it does very little to distinguish between desired and undesired sound. Thus, the user is still left on her own to sift out the noise from what **she** wants to listen to, and this is not a trivial task. (St4_06_4)

In professional EDRs, on the other hand, third person pronouns seem to be very topic-specific and appear with some frequency only in eight of 77 professional reports. Third person pronouns (**bolded**) are most commonly used in professional EDRs to refer to hypothetical human agents (<u>underlined</u>), in one way or another related to the design project, including an intruder of a self-securing storage device (6.28) or users of the modified smartphone device (6.29). Professional engineers sometimes also refer to real human participants of their design project (*italicized*), such as a driller in excerpt 6.30. It is also interesting to note that only one professional report used *she* to refer to a hypothetical female user of the designed device, and there were no inclusive forms *he or she* (or *he/she*) found in professional EDRs.

6.28 Determining how <u>the intruder</u> compromised the system is often impossible in conventional systems, because **he** will scrub the system logs. (Pr2_00_1)

6.29 <u>Bob</u> might guess, for example, that <u>Alice</u> has credentials that **he** could use, but **he** does not know exactly which of the credentials that **she** possesses will be helpful for this particular proof. It would be inefficient for <u>Alice</u> to send Bob all her credentials, since **she** might have hundreds. (Pr2_05_4)

6.30 By avoiding or correcting vibration, bit whirl, and stick-slip, *the coached driller* was able to advance the second hole from the 1100' starting depth to a final depth of 1615', and **he** only stopped at that point because no more time was available in the drill rig's test schedule. (Pr1_03_1)

Second person pronouns are extremely rare in both student and professional reports. In fact, in addition to the phrase "a pay-as-you-go model" used once in one professional EDR, only one additional professional EDR included one instance of *you* to refer to the reader (6.31). Interestingly, student writers also hardly use second person pronouns, with all instances of *you* being observed in just 15 of 77 reports. However, those student writers who use *you* seem to rely on it relatively frequently (6.32–6.35).

6.31 As **you** can see, the operation to calculate Q_star takes the square of the difference between the predicted state estimate and the final state estimate of each step and subtracts the expected difference. (Pr2_06_1)

6.32 When actually completing our code, we divided the code into sections to allow **you** to be able to implement the pieces **you** choose, and make changes more easily. (St3_10_1)

6.33 When **you** pass a signal through a filter the output is ideally a new signal without the unwanted or filtered frequencies. (St3_10_1)

6.34 This means that if f1 and f2 are equal, then **you** will get: [equation]
Which equals: [equation] (St3_10_1)

6.35 This makes sense considering that **you** are essentially multiplying a wave by itself. If **you** multiply this wave by the carrier wave again and then filter out the high frequency component: cos(2pf1 + 2pf2). This will get us back to a signal very close to the square wave and will look very similar to Figure 3. (St3_10_1)

Overall, the patterns of pronoun distribution across EDR registers seem to be closely connected to the distribution of the content word classes, which was expected. Thus, the higher frequency of nouns in professional reports corresponds to a lower density of pronouns in this register. On the other hand, the lower frequency of nouns in student reports is offset by the more frequent pronoun use by student EDR writers.

6.3.4 Verbs

Previous corpus-based research demonstrated that verbs can also be grouped into semantic classes (Biber, 2006a; Biber et al., 1999). Figure 6.4 shows the rates of occurrence for verbs in six of the semantic classes previously reported in Biber (2006a). This figure points to the heavy reliance of EDR writers in both settings on verbs in two semantic domains: activity verbs and mental verbs.

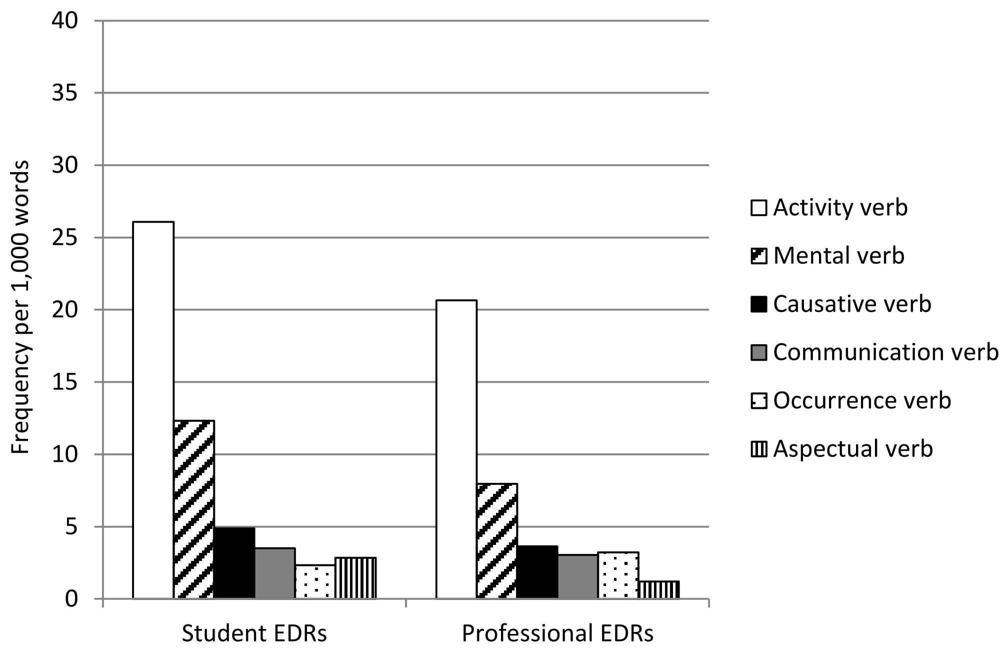


Figure 6.4 Distribution of verbs across EDR registers

As can be seen, student EDR writers rely on activity verbs (i.e., verbs primarily denoting actions associated with choice) to a much greater degree than do professional EDR writers. The results of the analysis demonstrate that activity verbs are commonly used by EDR writers in both settings to describe sequences of events and procedures, especially steps in design and testing procedures. Activity verbs also help EDR writers describe design data and results. Excerpts 6.36–6.37 illustrate the use of activity verbs (**bolded**) in student and professional EDRs.

6.36 To **fix** the imperfections in the wood, we **used** all-thread which is just long cylindrical material that is **threaded** so it can **act** like a screw. We **cut** two inch pieces of the all-thread and then **drilled** clearance holes through each of the levels to **fit** the pieces. We **fastened** nuts on either end of the all-thread so that the two pieces of wood were **pinched** against each other so the warping was no longer an issue. (St4_05_2)

6.37 We **set** szz equal to the compressive or tensile allowable design stress value depending on whether it is negative or positive. Then we **used** a Newton-Raphson scheme to solve Equation (1) and **obtain** the required unidirectional laminate thickness. (Pr4_04_1)

Mental verbs (i.e., verbs denoting a wide range of activities and states experienced by humans) are also used very commonly in both EDR registers. Similar to the patterns of use of activity verbs, engineering students use mental verbs significantly more frequently compared to professional engineers. Mental verbs (**bolded** in excerpts 6.38–6.41) are often used by EDR writers in academic settings for justifying their design choices (6.38–6.39) and for explaining problems encountered and subsequent troubleshooting procedures (6.40–6.41):

6.38 After receiving quotes from various vendors, it was **determined** that a half scale prototype with a ball & screw type assembly was not achievable due to a lump sum cost of approximately $2,000, clearly above our budget. After consulting with the various faculty members, it was **determined** to build a ¼ scale working model. (St6_03_2)

6.39 We **concluded** that the RC car would pose more problems than solutions. First, the RC car was designed to go much faster than our requirement. We **wanted** our robot to travel around 3 ft/sec and the RC car would go approximately 15 ft/sec. Second, control of the steering solenoid for the RC car was not well documented. Third, due to previous experience with differential steering from a previous course, we **chose** to use it instead of the RC car type design. After **deciding** to use differential steering, we then **chose** to use gear-head motors for our robot. Experience with gear head motors from a previous course aided us in this decision. We **chose** gear-head motors that would operate at 12 Volts with max rotations per minute (RPM) of approximately 400. (St6_4_23)

6.40 The gears **proved** to be the main source of friction. Prepackaged gearboxes for our application were approximately $400. This cost was approximately 40% of the entire budget hence it was **decided** to assemble the gears ourselves. As a result, the alignment of the gears **proved** to be a major task. (St6_03_2)

6.41 We **knew** that we **wanted** to use an Ackerman steering mechanism for the vehicle and this **proved** to be a very difficult thing to build from scratch. We eventually **found** a radio controlled (RC) car that had the components we **needed**. These parts were adapted to our design and we were able to assemble a prototype vehicle complete with the steering servo, drive motor, sensor array, microcontroller board and bread-boarded interface circuitry. Through thorough testing we **found** a few minor changes that **needed** to be made in the interface circuitry. (St6_4_24)

With the exception of the higher overall reliance of student writers on verbs in all semantic classes, the distribution patterns of verb classes in student and professional

EDRs presented in Figure 6.4 seem to be very similar. Interestingly, however, it can be seen that compared to students, professional writers use one particular class of verbs much more frequently, specifically occurrence verbs. These verbs (**bolded** in excerpts 6.42–6.43) report events occurring apart from any volitional activity (e.g., *become, change, grow, increase*) and are frequently used by practicing engineers to report results of analyses.

6.42 When the results were plotted for all of the corresponding sled and HCTD tests accomplished during CAMI's evaluation (including previous tests of various interior surfaces and the latest seatback tests), no clear correlation trend **emerged** (Figure 21). The degree of correlation varied significantly between the various surfaces impacted. The only discernable trend is that the correlation seemed to **decrease** as the stiffness of the surface being stuck **increased**. (Pr2_04_3)

6.43 As seen in figure 8, the CM mode frequencies **do not change** much with rotor speed. However, as the rotor spins, the theoretical tilt mode frequencies **do change** as a function of rotor speed; in fact, once the rotor is spinning, the tilt modes **become** whirl modes, which separate with speed into tilt forward whirl (FW) and tilt backward whirl (BW) modes, where FW rotation is in the same direction as rotor rotation, and BW rotation is in the direction opposite rotor rotation. The BW mode frequency **decreases** with rotor speed, while the FW frequency **increases** with speed, and theoretically asymptotes to Ip/It times the synchronous speed (1/rev) at high speeds (note that the D1 rotor Ip/It ratio is 0.8; in the simulation in figure 8, the FW mode reaches 800 Hz at 60 k rpm = 1000 Hz). (Pr3_05_3)

The results of the analysis of verbs according to their semantic meanings indicate both quantitative and qualitative differences in the use of verbs by student and professional EDR writers. The next subsection explores differences in the use of verbs further by examining one particular type of verb phrase, the passive voice.

6.3.5 The Verb Phrase: Passive Voice

Academic and professional writing has commonly been associated with the frequent use of passive voice. For example, Biber (2006a) identified an extremely high reliance on passive voice in engineering textbooks (almost 30% of all verbs). Passive voice is also a grammatical feature often stressed in technical communications courses and textbooks. The use of passive voice has often been linked to contexts where (a) actions and entities affected by actions are of the primary importance and/or (b) the agents of such actions are understood or unimportant.

Interestingly, the results of the present study (Figure 6.5) do not indicate significant differences between the rates of occurrence of passive voice structures in student and professional EDRs, though student writers appear to use slightly more agentless structures and writers in the workplace use slightly more *by*-passives. The results also highlight the fact that although both student and professional EDRs rely on the use of passive voice extensively (20% and 23% of all verbs, respectively), both EDR registers utilize active voice much more frequently (80% and 77% respectively).

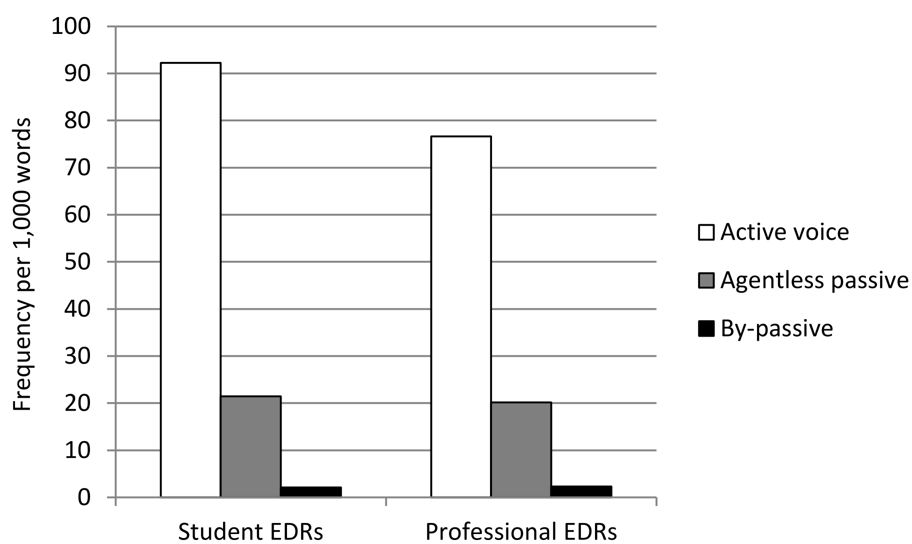


Figure 6.5 Distribution of active and passive voice across EDRs

Figure 6.5 shows that, consistent with previous research findings (Biber et al., 1999), agentless passives are much more common than *by*-passives in both EDR registers. Also in line with previous research, in both registers, agentless passives are commonly used to de-emphasize the role of the action agent. Frequently, these agentless passives are formed with activity and mental verbs (**bolded**) and used to describe design procedures:

6.44 Bg spores **were diluted** in sterile water to a concentration of 1X107 CFU/mL and 35 mL of the spore solution **was added** to the single-jet Collison nebulizer. Compressed air (20 psi) **was added** to the Collison nebulizer and allowed to equilibrate for 5 minutes. Glass coupons **were placed** in glass Petri dishes (Tisch Environmental, Cleves, Ohio), which **were loaded** into the collector. (Pr2_08_1)

6.45 The QE **was calculated** for various thicknesses, bandgaps and optical enhancement conditions and **integrated** with AM1.5 spectrum (IQE). The top cell **was modeled** with the following assumptions: (Pr4_08_2)

6.46 The calculated cutoff frequency **was set** slightly below 13 kHz due to the fact that general lab components **were used** and exact values were unavailable. (St6_03_3)

6.47 A roundabout **was selected** as the best form of intersection control. The proposed final design includes geometric, vertical, cross-section, signing, striping, and drainage designs which **were created** by following accepted manuals and standards. From these designs a final cost estimate **was** then **created**. (St3_10_7)

Agentless passives are also rather commonly used when EDR writers describe (a) what their designs consist of and (b) how these designs function (6.48–6.49). In such cases, the agents of the verbs are also frequently assumed to be the EDR writers.

6.48 The extraction system **is designed** to transport a representative sample of stack gas from the stack to the filter tape. It includes a probe, 1-inch-diameter tubing, stilling chamber, and flow measurement and control components. Temperature **is measured** at five locations, and all tubing prior to the filter is heat traced. (Pr5_05_1)

6.49 As the magnet **is immersed** in the fluid, the user has the option of turning on the current to the electromagnet. This way the MR fluid solidifies around the magnet and **is picked up** as the electromagnet **is raised**. Once the electromagnet **is raised** the current **is turned off** and the fluid falls freely back into the vat and splashes, allowing the user to see this transition from solid to liquid. (St6_03_11)

Interestingly, agentless passives describing procedures heavily rely on the past tense (6.44–6.47) whereas descriptions of designs (6.48–6.49) and discussions of background information generally utilize agentless passives in the present tense. This switch is made apparent in excerpt 6.50, where EDR writers switch from the past tense of the procedures (**bolded**) to the present tense when they provide background information (*italicized*). Note that when background is provided, the implied agents are no longer EDR writers.

6.50 Energy-Absorbing (EA) Seatback. A set of older, statically qualified, passenger double seats **was modified** by adding an energy-absorbing element to each seatback hinge mechanism. *An energy absorber of this type allows the seatback to stroke forward when a force of approximately 300 lb.* ***is applied*** *horizontally at the top of the tray table. This stroking action can significantly reduce the probability of head injury.* (Pr2_04_3)

Agentless passives in the present tense are also frequently used to refer EDR readers to particular data or visuals. Here, the implied agents are typically EDR writers and verbs commonly used include *demonstrate*, *depict*, *illustrate*, *plot*, *present*, and *show*.

6.51 A block diagram of the flow system used for our experiments **is depicted** in Figure 5. (Pr1_06_4)
6.52 The ability of the device to operate as an AND logic circuit **is demonstrated** in figure 7. (Pr3_06_3)
6.53 The design that matured from the block diagram **is presented** in Fig. 10. (Pr2_02_4)
6.54 The resulting magnitude and phase **are plotted** on Figure 21 below. (St3_10_1)
6.55 The GUI of the final version of the Voice Recognition Software, VCommander version 1.4 **is illustrated** in Appendix B. (St6_04_5)
6.56 Photographs of the testing prototype **are shown** in Figure 3.6. (St3_06_1)

Further, present tense passives, with EDR writers as implied agents, are frequently used to provide details about specific calculations. These passives commonly use such mental and existence verbs as *assume*, *calculate*, *compute, define*, *derive*, *determine*, and *multiply*, as seen in excerpts 6.57–6.63.

6.57 To date, analysis shows that the following conditions are true for the existing design, where the ramp angle is assumed to be 10 degrees and the coefficient of friction **is assumed** to be 0.065. (Pr1_02_1)
6.58 Test Load **is defined** as applied load times a safety factor of 1.5.(Pr1_00_1)

6.59 We note that fI **is derived** from the primary variable through the gradient operator while the J **is derived** by taking the curl of the vector potential.(Pr1_05_1)

6.60 The total gain of the amplifier **is determined** by the ratio of two external resisters Rr, R2, and the voltage divider.(Pr3_03_1)

6.61 Rural erosion values for all source area k on day t **are calculated** using the Universal Soils Loss Equation shown in equation 9. (St4_05_8)

6.62 Finally, an average line **is computed** from all pairs meeting these criteria, weighting each line's components (angle and distance) by its pixel support from the Hough accumulator. (St4_05_14)

6.63 The error **is multiplied** by a proportional constant, and the result is the first portion of the rotation factor. (St6_03_9)

In addition to the variation of use of tense marking, passives in student and professional EDRs seem to show different patterns of use in terms of aspect marking. In particular, perfect passive constructions are commonly used to report results of design projects overall or of their specific stages (6.64–6.69). These passive constructions, with EDR writers as implied agents, are frequently formed with such verbs as *develop*, *complete*, *conduct*, *perform* and *design*.

6.64 As a result of the erosive properties of atomic oxygen on polymers and composites, protective coatings **have been developed** and are used to increase the functional life of polymer films and composites that are exposed to the LEO environment. (Pr3_04_6)

6.65 Currently two rudimentary computer models **have been developed**. (Pr2_05_1)

6.66 A computerized method **has been developed** to aid in the preliminary design of composite wind turbine blades. (Pr4_04_1)

6.67 A scaling energy model, COTS FEA, and a proof-of-concept experiment **have been completed**. In addition a complete suite of magnetic diagnostics as well as photometric/optical and internal plasma measurements **have been constructed**. (Pr2_05_1)

6.68 A calculation **has been conducted** to obtain the noise level of x-ray (energy at 12.4 keV) and gamma ray (energy at 1 MeV) on GaN photodiodes by University of Washington (UW). (Pr3_05_1)

6.69 The improved modal controller described in this paper **has been** successfully **developed** and **implemented** and **has been used** for regular hands-free operation of the D1 flywheel module up to its maximum operating speed of 60,000 rpm. (Pr3_05_3)

Interestingly, not all verbs behave in the same way in perfect passive constructions. For example, the verbs *show* and *use* in present perfect passives are commonly used in introduction and discussion organizational units of EDRs to report previous work by others, and therefore their implied agents are not EDR writers.

6.70 Nebulizers **have been used** to successfully generate aerosols for a number of years (Ylatalo et al. 2000; Flagan and Seinfeld 1988; Fuchs and Stutugin 1966). (Pr5_05_1)

6.71 MIT-MANUS, developed nearly ten years ago (Hogan et al., 1995), **has been used** extensively in clinical trials with over 100 patients.(Pr1_04_1)

6.72 These merit functions are aggregate, energy weighted measures of TPV spectral performance and **have been shown** to correlate with the independently measured efficiency and power density of a combined TPV cell and spectral control configuration [20, 21] (Pr1_07_4)

6.73 One reason could be the microscopic nature of the polymer contact with the gate dielectric and the conductivity of the polymer due to unintentional doping of the polymer while handled in air, which **has been shown** to have a detrimental effect on the FET behavior in RRP3HT (ref. 21). (Pr3_06_1)

6.74 The temperature must also be taken into account since it **has been shown** to significantly affect the speed of sound in air. (St6_04_14)

6.75 For these reasons the Hough transform has become the standard method of line extraction [8], and it **has been used** in the line following algorithms of several robot systems [3][4]. (St4_05_14)

In contrast to agentless passives, common agents of *by*-passives (**bolded**), especially in professional EDRs, are abstract processes and concepts (<u>underlined</u>), often expressed through nominalizations.

6.76 The high-pressure gas then flows through the Turboalternator where it **is cooled** <u>by expansion</u> to a lower pressure and spins the turbine shaft at speeds up to 4500 rps. (Pr3_02_2)

6.77 Model performance **is validated** <u>by evaluating</u> the response of the phase compensation controller for step changes in utility voltage phase angle for voltage control mode and reactive power settings for current control mode. (Pr4_07_1)

6.78 Achievement of the overall goal of this **is affected** <u>by the economic reality</u> that the price of PV systems is prohibitive to many individuals and organizations that might otherwise want to have such systems installed. (Pr1_02_2)

6.79 The lateral bracing arrangement, shown in Figure 4.5, **was determined** <u>by assessing</u> the necessary spacing to support the decking support surface, withstanding the induced lateral forces, and <u>creating</u> rigidity in the truss. (St3_10_14)

6.80 The values below **were obtained** <u>by averaging</u> the results obtained from the positive and negative unidirectional repeatability experiments. (St6_05_4)

6.81 Crude oil and natural gas **are extracted** <u>by</u> first <u>penetrating</u> the earth crust to a depth where a reservoir exists. (St6_04_3)

This pattern can be found both in student and professional EDRs; however, student writers also seem to commonly use *by*-passives (**bolded**) to discuss actions of human agents (<u>underlined</u>). Frequently, these human agents are hypothetical users of the design (6.82–6.83) or clients (6.84), but sometimes students refer to their own teams and their members (6.85–6.86).

6.82 The quadrature encoder **is used** <u>by mudloggers</u> in the oil and gas business. (St6_05_9)

6.83 The write on update checkbox sets whether the parameters are automatically resent when a parameter value **is changed** <u>by the user</u>. (St4_06_1)

6.84 The only problem worth noting with the development of the code was due to some lack of clarity of the sample files sent by the client. There was some ambiguity as to how the sample files **were created** (e.g. if they **were** already **linked**) and if that **was** an assumption **made** <u>by the client</u> as to the type of input the final product required.(St2_03_14)

6.85 It **is used** <u>by our design team</u> conservatively since the final design should have better board frequency response than the current design.(St3_05_1)

6.86 All calculations **were reviewed** <u>by at least one team member</u> that did not perform the calculations. (St3_10_14)

6.3.6 Modals

Because modals are frequently used to express possibility or obligation, they have been generally examined as part of studies focusing on the expression of stance, both in conversation and academic writing (Biber, 2006b). Comparing the distribution of modals in conversation, fiction, news, and academic speech, the LGSWE reports that while modals are common in all these registers, they are most common in conversation, with *will*, *would*, and *can* being the most frequent. According to the LGSWE, in academic writing the most frequently used modals are *can*, *may*, and *will*. Figure 6.6 shows the distribution of modals in professional and student EDRs.

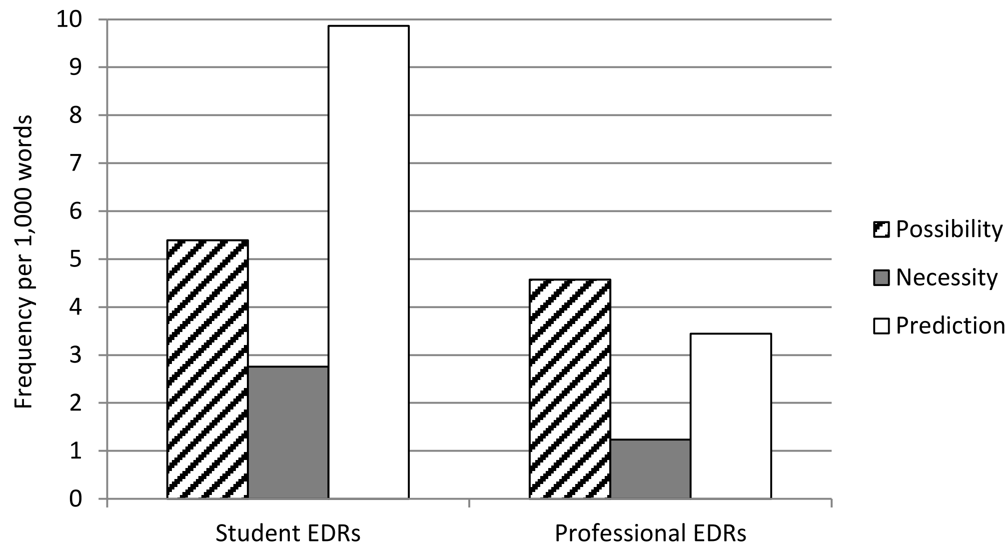


Figure 6.6 Distribution of modals across EDRs

Considering that student EDR writers overall rely on verbs and clauses more frequently than do practicing engineers, it is not surprising that student EDRs show much more frequent use of modals in all three individual categories, with the most remarkable difference in the use of modals of prediction. In this category, the student EDRs use almost three times as many modals as do EDRs written by practicing engineers in the workplace.

This extremely frequent use of prediction modals in student reports is unusual, but can be explained by the fact that many student projects are still approaching to be finished at the time these reports are written; therefore, some stages of the design projects can be described in the future tense, using prediction modals (6.87). In addition, modals of prediction are used more frequently in specific engineering disciplines. For example, students in civil engineering rely on prediction modals to discuss conceptual designs, or designs that do not involve physical construction of a prototype and exist only on paper (6.88).

6.87 A prefabricated concrete culvert structure **will need** to be placed at a diagonal angle through the dam so as to follow the path of the channel bottom. The culvert **will measure** 3'W3'H45'L and **will be composed** of four 10'L sections joined together by preformed rubber gaskets or rubber strips. To prevent debris from entering the culvert, large rocks **will** be placed immediately upstream of the entrance. The spillway **will be poured** concrete and **will span** 30' on the top of the dam. There **will be** a prefabricated bridge spanning the spillway with guardrails on both facing sides to allow passage over the spillway with minimal potential for human harm. The dam **will** also **feature** a pathway made of either asphalt or concrete, 9' wide, spanning the entire length of the bridge. This **will be** used to join into any future planned trail system and is wide enough to support both bicycle and pedestrian traffic. There **will be** guardrails along the entire span of the bridge as well to prevent traffic from veering off the trail and falling from the dam. (St3_10_11)

6.88 The diversion dam **will** be designed to withstand a minimum of a 50 year flood as requested by the property manager. However, if ADWR dam safety regulations are more stringent we **will** design according to their criteria. To determine an estimate of what the 50 year flood **will** be like a hydrologic and hydraulic analysis **will** be completed. (St3_10_6)

In addition, student EDR writers use prediction modals for a variety of other purposes, including providing recommendations to future students (6.89–6.90), discussing alternative designs (6.91), describing hypothetical situations in the future (6.92), and highlighting user benefits (6.93).

6.89 The main thing that **would have been** done differently if the project was to be done again **would be** to more clearly define the interfaces between different parts of the process before implementation was to be done. This **would have allowed** more of the software application to be developed in parallel. (St2_03_14)

6.90 In the Fall semester, make potential connection prototypes. Practice putting pieces together and time the fabrication. It **will be** a valuable way to differentiate between a "good" connection design and a "theoretically good" connection design. Also, this **will provide** an estimate for how much work **will be required** in the fabrication of such pieces. (St3_10_14)

6.91 The next major design decision was the pulse width modulation (PWM) source. A PWM IC or a Microcontroller can be utilized for this logic block. A PWM IC **will** be lower in cost to implement and manufacture but **will not allow** any extra functionality. A microcontroller **will cost** more but **will give** the user much more functionality and give [company] the ability to upgrade and add extra peripherals relatively easily. Some of the extra peripherals are to optimize performance and offer a wider range of functions. A PWM IC has been chosen simply for cost. (St3_10_15)

6.92 [Company] has also tabulated quite a few administrative/housecleaning type issues that have been decided and are being or **will be acted upon** as soon as possible. The main branch office **will be located** in northwest [City], [State] and have rather loose operating hours as it's two representatives will be on call for the first year of sales. In the first year of sales [company] believes it can sell roughly 23 bulbs per month (based on survey responses) for the year, yielding a profit of $12,141.24 (as the sales representatives **will be working** pro bono for the first year). Now assuming [company] creates a larger product line and increases sales by a conservative 5% per month after the first year, net profits on the second year's end can be seen at roughly $57,768.47 assuming [company] hires 5 minimum wage kiosk salespeople that **would work** 20 hours per week 52 weeks per year. Progression of profits **would rise** accordingly over the following years with the only main hit to profits being the addition of sales people and advertising costs. [Company] assumes another 20% of profits **will account** for these additions and kiosk/advertising costs.(St6_03_1)

6.93 The display case is fully interactive and self-explanatory. The user **would have no problems** operating each experiment. Nevertheless, instructions for each experiment are included. In addition, a brief background of the history of Magneto-Rheological fluids **will be exhibited** behind the experiments. Confidently, this display case **will interest** by-passers and **will help** to raise their awareness about the MR fluids, therefore fulfilling its purpose. (St6_03_11)

Interestingly, student EDRs frequently use the modal verb *shall*, which, according to the LGSWE, is extremely rare in academic writing. Generally, the use of *shall* can be explained by specific functions of this verb in some engineering disciplines, such as civil and environmental engineering for example, where *shall* is used to state required, mandatory, or specifically prohibited practices (6.94). Other modals are then used for other specific purposes. For example, *should* is typically used for statements of recommended, but not mandatory, practices in typical situations, with deviations allowed if engineering judgment or engineering study indicates the deviation to be appropriate. *May* is generally used for statements of practice that are permissive conditions and carry no requirement or recommendation.

6.94 Prior to placing fill, the existing surface **shall be prepared** by: scarifying to a minimum depth of 6in and removing material larger than 3 inch size, then moisture conditioning to between - 1% and +3% of optimum moisture (or as directed in the geotechnical report), and then compacting to a minimum of 95%. Compaction **will be done** using the Modified Proctor (ASTM D 1557), for all laboratory reference curves on all County projects. All references to percent compaction in the County Earthwork Standards **shall be** to ASTM D1557 (not ASTM D698). Fill **shall contain** no material with dimensions greater than 3inch size within the upper 24 inches. Fill placed in depths deeper than 24 inch below finished sub grade may contain material larger than 3 inch diameters. Cinders **shall not be used** as fill material, unless specifically approved by the County. All fill **shall be placed** in horizontal lifts. Loose lift thickness **shall be limited** to 8 inch maximum. (St3_10_13)

6.3.7 Features of Grammatical Complexity across EDR Registers

Table 6.2 shows the distribution of several features associated with grammatical complexity that were examined in the present study, specifically, type-token ratio, average word length, nominalizations, and prepositions in the two EDR registers. As can be seen, professional EDRs have the highest type/token ratio, average word length, and numbers of nominalizations and prepositions. The higher type/token ratio, frequency of nominalizations, and longer average word length in professional EDRs suggest that EDR writers in the workplace use more specialized and technical vocabulary than do student EDR writers. While technical terms are common in both EDR registers, practicing engineers not only seem to use technical and process nouns more frequently than engineering students (see Figure 6.2), but professional engineers also appear to use more varied and sophisticated vocabulary that distinguishes this register.

Table 6.2 Selected features of grammatical complexity across EDR registers

Register	type/token ratio	average word length	nominalizations	prepositions
Student EDR	31.884	4.902	64.560	103.770
Professional EDR	32.727	5.012	70.424	116.268

Table 6.3 displays the rates of occurrence of conjunctions used by EDR writers in the two settings. The results of the analysis show that subordinators are relatively rare in both EDR registers, but somewhat more common in student EDRs than in EDRs written by practicing engineers. On the other hand, coordinating conjunctions are used with relatively equal frequency in academic and professional settings. This distribution reflects the fact that complexity in academic and professional writing resides at the phrase rather than at the clause level, a result previously reported by Biber et al. (1999) in the LGSWE. Further, the slightly higher rate of occurrence of subordinators in student EDRs is probably connected with the higher frequency of verbs in these reports (see Figure 6.4), which indicates that student EDRs consist of more clauses. This higher number of clauses, in turn, leads to the greater need for clause-level connectors. In contrast, professional EDRs have a higher frequency of nouns and also a higher frequency of prepositions, which specify or extend nouns. Differences between the distributions of conjunctions in the two EDR registers are rather subtle. These results corroborate the results of previous research. Specifically, Biber et al. (1999) found much less marked register differences with coordinators and subordinators than with the function words that operate specifically at the phrase level (i.e., prepositions, pronouns, auxiliaries), concluding that "register differences are more connected with the build-up of phrases than with the connection of clauses" (Biber et al., 1999, p. 93).

Table 6.3 Conjunctions across EDR registers

Register	subordinating conjunctions (causative)	subordinating conjunctions (conditional)	subordinating conjunctions (other)	coordinating conjunctions (clausal)	coordinating conjunctions (phrasal)
Student EDR	1.230	1.5876	3.622	6.164	2.217
Professional EDR	0.774	0.8744	3.171	6.249	2.212

Figure 6.7 shows that similar to the findings reported in the LGSWE, EDR writers in academic and professional settings use *that*- and *to*- complement clauses the most, seldom relying on *wh*-clauses. Notably, the large majority of *that*- and *to*-clauses in both EDR registers occur in post-predicate position after verbs, followed by clauses controlled by adjectives, and nouns. It can also be seen that, compared to professional EDRs, *that*-, *to*-, and *wh*-clauses are used more frequently in student EDRs, with an especially high frequency of *to*- complement clauses. The overall lower frequency of complement clauses in professional EDRs could be ascribed to the fact that complement clauses are "typically used to complete meaning relationship of an associated verb or adjective in a higher clause" (Biber et al., 1999, p. 658). Professional EDR writers, however, rely on the use of verbs to a much lesser degree than do engineering students, which likely affects the overall distribution of complement clauses in this register.

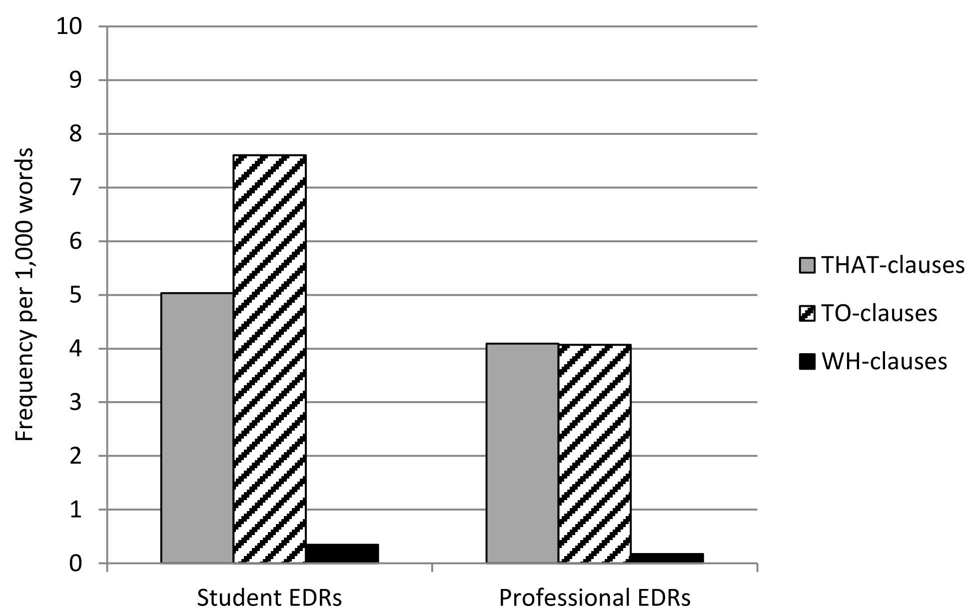


Figure 6.7 Complement clauses across EDR registers

The analysis of the features associated with grammatical complexity reveals that, compared to engineering students, professional EDR writers use more varied and sophisticated vocabulary as indicated by the higher type/token ratio, frequency of nominalizations, and longer average word length found in professional EDRs. Professional EDR writers also heavily rely on prepositions, resulting in highly compressed and information-dense prose. Taken together, the higher type/token ratio, the longer average word length, the frequent rates of occurrence of nominalizations and prepositions in professional EDRs point towards a greater overall grammatical complexity of EDRs written in professional settings.

Interestingly, the distributions of conjunctions in the two EDR registers were quite subtle, suggesting that register differences are more associated with the distribution of the function words that operate at the phrase level (e.g., prepositions, pronouns, auxiliaries) than with the differences in distribution of coordinators and subordinators.

6.4. Summary

The results of the analysis of core lexico-grammatical features of student and professional EDRs show complex patterns of linguistic variation. One of the most interesting findings of the study is that the overall patterns of use of most linguistic features examined in this study were found to be rather similar in student and professional EDRs. This finding suggests that by their senior year, engineering students have learned to replicate professional engineering discourse, if not perfectly.

Another interesting result of the analysis is that the most prominent differences between student and professional EDRs seem to be related to the distribution of nouns and verbs in these two registers. The patterns of distribution of nouns and verbs, in turn, have been found to be closely connected to the distribution of other content word classes, such as adjectives, and function words, such as pronouns, modals, and prepositions. It has been observed that the higher frequency of nouns in professional EDRs corresponded to a lower density of pronouns in this register; conversely, a lower frequency of nouns in student EDRs is offset by the more frequent pronoun use by student EDR writers.

This interconnected phenomenon between linguistic features and their distribution patterns in student and professional EDRs results in two EDR registers that fill different positions on the spoken-to-written continuum. Specifically, the heavy reliance of student EDR writers on such features as verbs, pronouns, and modals, typically associated with clausal elaboration preferred by spoken rather than written registers, results in more narrative, less information-dense EDRs. On the other hand, professional EDRs showed more frequent use of nouns, adjectives, prepositions, and nominalizations associated with highly compressed information-packed academic and professional written prose.

These findings can be explained by the situational characteristics of EDRs written in academic and professional settings. In particular, the primary communicative purposes for writing EDRs for grant-issuing agencies is to satisfy contractual requirements, share technical information with colleagues early in the information flow process, and keep records. To disseminate information to colleagues working in a variety of professional environments, frequently including those who work in governmental research and development labs and research institutions, EDRs writers may feel required to use highly compressed information-packed written prose, commonly used in these environments and expected by such audiences.

In academic environments, on the other hand, the communicative purposes frequently revolve around pedagogical objectives of the design course(s), including displaying information known in the field, showing knowledge of one's project, and demonstrating ability to analyze data and write EDRs. Importantly, students write primarily for their instructor(s), who evaluate students' performance based not only on the quality of their writing, but also on a number of other performances, such as showing progress in learning content, team work, and even attendance and participation in class activities. Therefore, the quality of the student writing is not as important in this context as student learning of engineering content and other professional behaviors. While students are learning professional expectations and course content, they are also learning professional and academic discourse conventions. Results of the study show that students, by this time in their studies, have not yet mastered professional discourse as indicated by the conversational features in their writing.

Further, the analysis of the features associated with grammatical complexity provides additional insights into the variation between EDRs written in two different settings. The analysis included features that have been shown to indicate lexical specificity (e.g., type/token ratio, average word length), signal information density (e.g., nominalizations), and suggest syntactic complexity (e.g., prepositions, subordinators, and coordinators). The results of this analysis demonstrate that not only professional EDR writers rely on nouns and nominalizations more frequently than engineering students, but that practicing engineers also use more varied and sophisticated vocabulary as indicated by the higher type/token ratio and longer average word length found in professional EDRs. Interestingly, the differences in the distributions of conjunctions in the two EDR registers were quite subtle, suggesting that register differences could be revealed more readily by examining the distribution of function words operating at the phrase level (e.g., prepositions, pronouns, auxiliaries) than by analyzing coordinators and subordinators. Even with the observed subtle differences in the distribution of conjunctions, the combined higher type/token ratio, the longer average word length, and the much more frequent rates of occurrence of nominalizations and prepositions in professional EDRs point towards a greater overall grammatical complexity of EDRs written in professional settings.

CHAPTER 7. THE RHETORICAL STRUCTURES AND LINGUISTIC CHARATERISTICS OF PROFESSIONAL ENGINEERING DESIGN REPORTS

7.1. Introduction

Different approaches to genre analysis exist, as discussed in Chapter 2, yet the main objective of such analyses is to investigate discursive practices to gain a better understanding of "the disciplinary, institutional, organizational or professional practices of specialist communities" (Bhatia, 2006, p. 14). Thus, language genres can be viewed as consisting of two main components: the language used in the discursive practices and the context within these practices take place (Askehave & Swales, 2001). In this view of a genre, the "end users" of a genre are the members of particular discourse communities. These discourse communities use various genres to accomplish their sets of common goals. It is easy to see then that genres strengthen the bonds between the members of discourse communities and exclude others from the community. These functions are accomplished through the use of specific mechanisms for communication, including those of common discourse structures and linguistic choices.

To provide a more comprehensive picture of the EDR genre and to typify effective EDRs, this chapter investigates discourse structures and linguistic choices of professional EDRs. The chapter includes two sections that discuss two complementary analyses: a genre-based move analysis of the rhetorical structure of professional EDRs and a register-based linguistic analysis of the major rhetorical units of professional EDRs. Section 7.2 presents results of the move analysis, which provides a description of the rhetorical structure of the major organizational units identified within EDRs and their constituent moves. The move analysis concludes with a proposal of a representative model of the overall move structure of EDRs. The procedures for the genre analysis are described in Chapter 5 Section 5.3. Building on the findings of the genre analysis, Section 7.3 reports on the corpus-based analysis of linguistic variation in major rhetorical units of professional EDRs. The procedures for this analysis are described in Chapter 5 Section 5.2. The chapter concludes with a synthesis of the two analyses by presenting a simplified model of the EDR overall move structure that also reflects prevalent linguistic choices of professional EDR writers.

7.2. Genre Analysis of Professional EDRs

To analyze the overall structure of professional EDRs, the two coders and the researcher worked to identify both general organizational units of EDRs, often assumed to be Introduction, Methods, Results, Discussion, Conclusion, and Recommendations (IMRDCR), and specific moves within them. It was particularly important to determine the communicative functions of the moves, the boundaries between them, their sequences, and prevalent patterns. Analyses continued until main patterns (and their variations) became evident.

While the general steps of the move analysis described in Section 5.3.2 were followed, the present exploratory study could only stay at a relatively general level of major organizational units and prominent macro-moves, rather than provide a more detailed traditional move analysis. In this, the present exploratory study follows Chang and Kuo (2011), who define a move as "an information unit that performs a specific rhetorical function" (p. 224). Thus, all moves occurring in all organizational units were identified and coded according to their general rhetorical functions, which sometimes resulted in the same moves being found in different organizational units. For example, the Background move, in which EDR writers provide pertinent information about something that is typically discussed in a move that immediately follows, was observed in several organizational units.

After such general moves were identified in all professional EDRs in the corpus, move sequences in each professional EDR were entered into a spreadsheet file, so that each cell corresponded to each move in a particular organizational unit. All cells with moves were then color-coded to facilitate the search for the most prototypical move patterns. Figure 7.1shows a color-coded spreadsheet (but in black-and-white) for the EDR Introduction unit. The color-coded spreadsheets for each organizational unit were then used as input for the move-sequence analyses. Specifically, move labels in each spreadsheet column were sorted and counted so that the most frequent moves could be identified for each particular move slot, or position, within a sequence of moves in an organizational unit. For example, Figure 7.1 illustrates that the first move slot (column M1) of the EDR Introduction unit is most frequently occupied by the Background move. Using the spreadsheet, the number of occurrences of Background moves was counted for all move slots in which this move was found in the Introduction unit. This information was then entered in a table showing the distribution of moves by move slots in the Introduction unit. In the same way, the number of occurrences of each move found in a particular unit (e.g., the Procedures move in the Methods unit) was counted for all relevant move slots and entered in tables showing the distribution of moves by move slots in that particular unit.

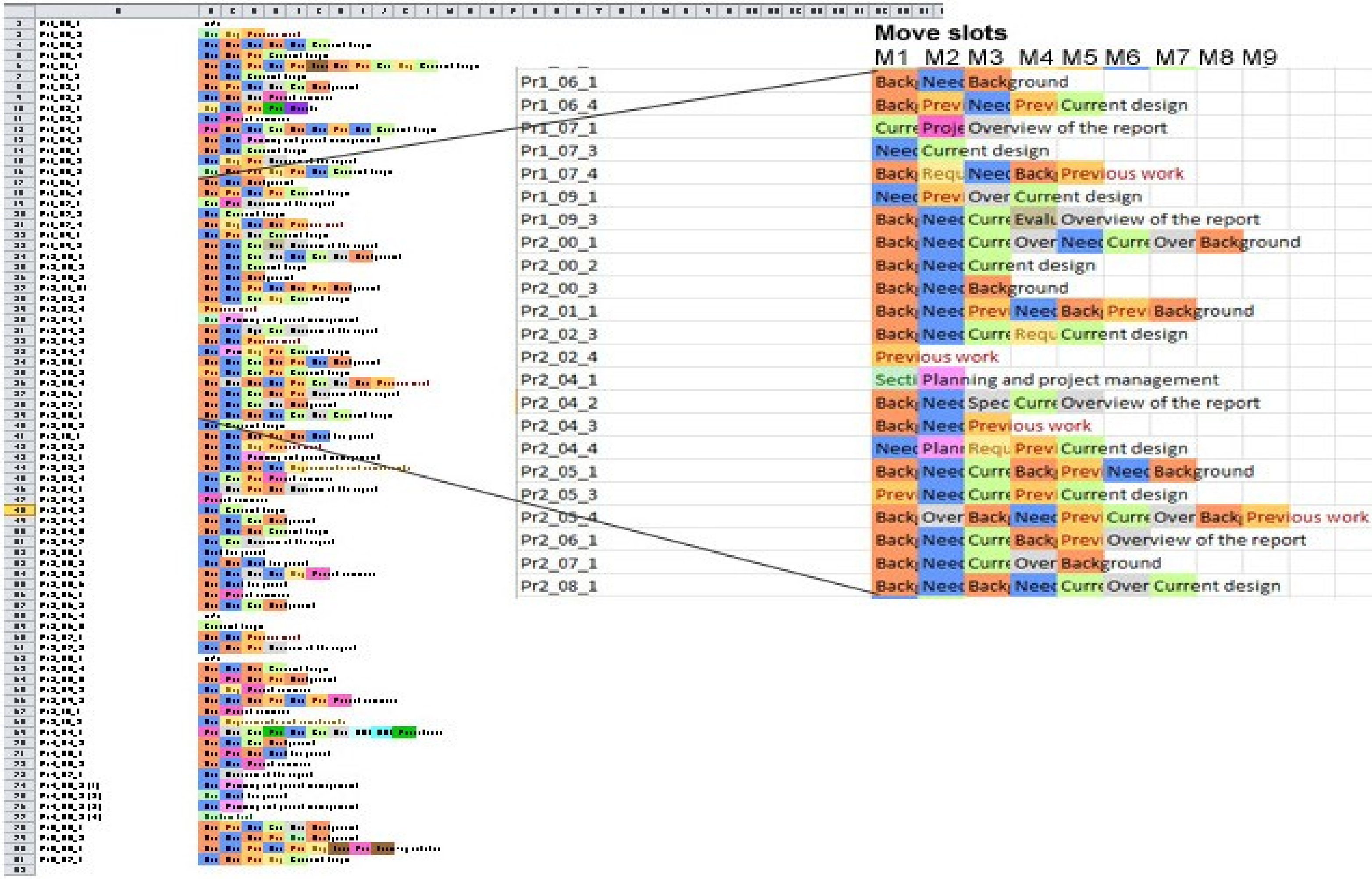


Figure 7.1 Color-coded move sequences with move slots shown in EDR Introduction units

The following subsections present the genre analysis of the EDR main organizational units (i.e., IMRDCR). Only organizational units belonging to the report's body were coded for moves in the study. Therefore, Abstracts (A) and Executive Summaries (ExS), which belong to the report's front matter, were only checked for presence or absence and not further coded for moves. The results of the analyses are presented following the order in which these organizational units typically appear in professional EDRs: Introduction, Methods, Results, Discussion, Conclusion, and Recommendations. Further, the analyses revealed that professional EDR writers frequently use merged organizational units, such as Methods and Results or Results and Discussions. These merged units will be discussed below alongside their stand-alone counterparts. For each organizational unit presented below, only prominent moves will be discussed and illustrated. All EDR moves identified in this study and their examples can be found in Appendix K.

7.2.1 Overall Structure of Professional EDRs

Table 7.1 shows most common organizational patterns of overall EDR structure that emerged during the genre analysis. The two most frequent patterns, specifically A – IMRC and A – I[MR]C (with brackets signifying merged organizational units), account for more than a third of the professional EDR corpus. Although these two patterns were found in roughly equal numbers of EDRs, the A – IMRC pattern was observed in EDRs from all five report databases whereas A – I[MR]C was found in only three databases. Thus, the A – IMRC pattern appears to be more widely used by professional EDR writers.

Interestingly, the two most common EDR organizational patterns do not contain Discussion or Recommendation units, but they do include stand-alone Conclusion units. In fact, the results of the analysis suggest that practicing engineers rarely write a stand-alone Discussion unit; only 19 EDRs (out of a total of 80 EDRs) included a Discussion unit. Further, professional EDR writers hardly ever include a stand-alone Recommendations unit, preferring instead to incorporate their design recommendations in other organizational units. The Recommendations unit was found in only three EDRs in the professional corpus.

Table 7.1 Frequent patterns of overall EDR structure[a]

Pattern	Number of reports with pattern (n=80)	Percentage of corpus	Number of databases with pattern (n=5)
A – IMRC	15	18.75	5
A – I[MR]C	14	17.50	3
A – IM[RD]C	5	6.25	2
A – IMRDC	4	5.00	2
A – I[MR]DC	3	3.75	2
AExS – I[MR]CD	3	3.75	1
A – I[MR]D	3	3.75	2
I[MR]	3	3.75	3
Other patterns	30	37.50	5

[a] brackets indicate merged organizational units

The next two most frequent patterns are variations of the first most preferred pattern. They include a Discussion organizational unit, either as a part of a merged Results and Discussion unit (A – IM[RD]C) or as a stand-alone Discussion unit (A – IMRDC). These two patterns account for over 10% of the corpus and were found in only two different report databases each.

Less frequent were four other organizational patterns, which only occurred in three EDRs each, or 3.75% of the corpus. Three of these patterns incorporate Discussion as a stand-alone organizational unit. The stand-alone Discussion unit was observed in three positions: preceding the Conclusion unit (A – I[MR]DC), following the Conclusion unit (AExS – I[MR]CD), and without the preceding or following Conclusion unit (A – I[MR]D). Interestingly, the second of these three patterns includes an additional organizational unit not found in other relatively prominent organizational patterns, specifically the Executive Summary (ExS). Surprisingly, in this pattern, the Executive Summary unit is included in addition to the Abstract. The last pattern found in three EDRs (I[MR]) appears to be a much abbreviated version of the second most frequent pattern (i.e., A – I[MR]C) but without an Abstract and Conclusion. Unlike the other patterns found in three EDRs, only the I[MR] pattern was found in three different databases, making it a slightly more preferred pattern among the four.

Finally, the table shows that a variety of other organizational patterns, each occurring in only one or two reports, was observed in over a third of professional EDRs. This finding suggests that the EDR is a much less rigid genre than a RA because it allows for a greater variation of EDR rhetorical patterns. This variation is likely to be a product of several factors, one of which can be requirements set forth by specific governmental programs under which research and development projects are carried out.

Another factor that is likely to influence EDR rhetorical organization is the engineering discipline with which a design artifact and, therefore, an EDR are most closely aligned. Table 7.2 displays the distribution of EDR organizational units in the professional corpus by engineering disciplines. As the table shows, in five of the eight organizational units, the majority of texts belong to the "other engineering discipline" category, which, in this study, includes computer, electro-mechanical, environmental, and nuclear engineering as well the "unclear" category, for which a specific engineering discipline could not be clearly determined. Therefore, although disciplinary variation most likely affects the rhetorical, and possibly linguistic, characteristics of professional EDRs, pinpointing it proved to be challenging, considering the composition of the professional corpus and the often interdisciplinary nature of engineering design projects.

Table 7.2 Professional EDRs and their organizational units by discipline

Organizational unit	Number of units	Electrical engineering	%	Mechanical engineering	%	Other engineering disciplines
Introduction	77	20	95	27	93	30
Methods	40	7	33	14	48	19
Results	34	9	43	10	35	15
Methods and Results	37	12	57	13	45	12
Discussion	20	7	33	3	10	10
Results and Discussion	10	1	5	5	17	4
Conclusion	65	19	91	25	86	10
Recommendations	5	1	5	1	4	3
Full reports	***80***	***21***		***29***		***30***

Despite a great deal of variation, the results of the analysis show that all frequent rhetorical patterns in professional EDRs include three organizational units, Introduction, Methods, and Results, either as stand-alone or merged units. The most common patterns of professional EDRs also include Abstracts and Conclusions. Many of the less frequent EDR organizational patterns also include the Discussion unit, mostly standing on its own but sometimes merged with the Results unit. Findings of the analysis also reveal that despite the fact that five out of the eight most common EDR organizational patterns include merged Methods and Results units [MR], stand-alone Methods and stand-alone Results units are used just as frequently. In fact, 40 professional EDRs in the corpus included a stand-alone Methods unit, 34 EDRs contained a stand-alone Results unit, and 37 EDRs included a merged Methods and Results unit.

The following subsections examine the common moves in each of the EDR organizational units, both stand-alone and merged. Only selected moves that occurred in 20% or more of particular organizational units will be discussed in detail in these subsections; less prominent moves with examples can be found in Appendix K. Each subsection below first reports on the results of the unit's move frequency analysis. Individual frequent moves found in particular organizational units are described next and illustrated with examples. Each subsection then presents the discussion of the move sequence patterns. Note that in each table showing the sequence of the most frequent moves for a particular organizational unit (e.g., Background move in the Introduction unit), the shaded cell(s) with bolded number(s) represent the most frequent move(s) and the number of reports with it for a particular move slot in the unit. The unshaded cell(s) with bolded and italicized number(s) indicate the second most frequent move(s) for the same move slot. Also note that the second most used moves found in only one EDR are not bolded and italicized. Finally, each subsection below concludes with a proposed model of common moves representing a particular EDR unit. The unit models include relatively obligatory moves (each occurring in approximately 50% or more of particular EDR units) and optional moves (each occurring in approximately 40% or more of particular EDR units).

7.2.2 Introduction

The purposes of the EDR Introduction organizational unit are to introduce the reader to the design project and provide the reader with information necessary for understanding the research and development efforts discussed in the report. Numerous scholars have examined introductions in research articles (RAs) in a variety of disciplines

(Anthony, 1999; Kanoksilapatham, 2003, 2005, 2007, 2012; Samraj, 2002, 2005; Stoller & Robinson, 2013; Swales & Najjar, 1987). This research has been largely inspired by the Create a Research Space (CARS) model (Swales, 1990) created for RA introductions. The CARS model (briefly discussed in Section 5.3.1) includes three moves: Establishing a Territory, Establishing a Niche, and Occupying a Niche. This sequence, however, may vary between different instances of a genre, that is, some moves may be optional whereas some may occur in a different order, embedded in others, or repeated. The results of studies of RA introductions have demonstrated that this section's rhetorical organization generally follows the pattern of moves described in the CARS model, though variations exist and typically can be attributed to specific disciplinary influences. Previous research findings also suggest that more deviations from the CARS model and more cyclical organization of certain moves are typically observed in longer RA introductions (Crookes, 1986; Kanoksilapatham, 2005).

The results of the analysis of the EDR Introduction unit's rhetorical structure show many similarities to Swales' CARS model. In particular, the most prominent moves in EDR Introductions – the Background, Need for Project, and Current Design moves – could be said to roughly correspond to the three moves of the CARS model. For example, similar to Swales' Establishing a Territory move, the purpose of the Background move in the EDR Introduction unit is to create a context shared by the reader and the writer (i.e., essentially help establish "common ground" or territory). In this move, EDR writers typically show the importance of a particular research and development area and provide pertinent information about it. Despite similarities between the moves identified in EDRs and those of the CARS model, new labels were adopted for the moves in EDR

Introduction units because it is believed that the new labels would resonate better with engineering faculty and students, the intended end users of the current research. Six frequent moves of the Introduction unit are discussed below in detail and illustrated with several examples from the professional EDR corpus. Other, less frequent moves identified in the Introduction unit are listed in Table 7.4 and further described in Appendix K. Before the Introduction moves are discussed, however, the results of the move frequency analysis are presented.

7.2.2.1. Move Frequency Analysis

Table 7.3 shows moves found in the Introduction organizational unit, presented in the order of their frequency. Note that three EDRs did not contain the Introduction unit at all whereas one EDR included four reports, so the frequency counts for the Introduction unit are based on 77 EDRs that included the Introduction unit. As the table shows, the most frequent move in the EDR Introduction is the Need for Project move (87.01%), followed by the Background (66.23%), Current Design (48.05%), and Previous Work (40.26%) moves. Other frequently used moves include the Overview of the Report and Project Summary moves. The paragraphs below describe these most prominent moves and illustrate them with examples.

Table 7.3 Frequent moves of the EDR Introduction unit

Move	Number of EDRs with the move (n=77)	Percentage of EDRs with the move (%)
Need for project	67	87.01
Background	51	66.23
Current design	37	48.05
Previous work	31	40.26
Overview of the report	19	24.68
Project summary	16	20.78

7.2.2.2.Frequent Moves of the Introduction Unit

The moves described below are presented in their order of general appearance in the Introduction unit. Typically found in the very beginning of the EDR Introduction unit, the Background move helps EDR writers introduce the area of their research and development efforts, establish its importance, and provide background information necessary for the understanding of the design project. The following examples from professional EDRs illustrate these trends, with statements referring to the project's importance **bolded**.

7.1 There are **a variety of new research avenues** in thermophysical science and engineering technology development that require optical access to high-temperature and high-pressure environments. **Applications of these techniques are contributing to** materials synthesis research, pressurized water reactor studies, and supercritical fluids research. (Pr1_00_4)

7.2 Silicon carbide (SiC) is **widely known for its potential** as a structural material for MEMS devices designed to operate in harsh environments (i.e., high temperature, radiation, wear, etc.). It has robust mechanical properties that make SiC very attractive for RF MEMS applications. When used as the structural material in micromachined bridges, the inherent stiffness and tensile stresses of SiC results in beams that are extremely resistant to sagging. Moreover, its chemical inertness makes SiC highly resistant to stiction. **These properties make SiC an ideal alternative to metals** in surface micromachined bridge-based RF MEMS switches for the reasons described above. Incorporation of insulating, amorphous SiC as the main mechanical structure in bridge-based RF switches eliminates the need to use a stiction-preventing insulating film between the cantilever and transmission because the SiC itself is highly resistant to stiction, due to its chemical inertness coupled with its resistance to oxidation. (Pr3_08_4)

7.3 Cazenovia Creek, located in western New York State, is **the largest tributary of the Buffalo River** (Fig. 1). Its basin is **subject to heavy lake-effect snow** from Lake Erie, and **spring runoff typically has a strong snowmelt component**. During most winters, ice covers 80–100% of the surface of the creek, and its average thickness ranges from 1 to 2 ft. **Breakup ice jams form nearly every year** during mid-winter or spring thaws, and flooding occurs along the lower basin in the City of Buffalo and the Town of West Seneca about every 2–3 years. Some of these floods have caused **damages exceeding $1,000,000, and one death** has occurred. (Pr5_00_1)

The Need for Project move, which typically follows the Background move, discusses the limitations of currently used designs. This move's main function is to establish the purpose for the design project. To do so, EDR writers sometimes describe certain drawbacks of the previous designs (7.4–7.8). In this function, the Need for Project move is similar to Swales' Establishing the Niche move in which RA authors typically identify gaps in the previous research (e.g., previously unanswered questions, poorly understood or studied areas, procedures in need of improvement). Note how the Need for Project move with this particular function frequently starts with *however* (7.4, 7.8) and contains such words describing drawbacks of previous research and development attempts as *problem*, *limiting*, *difficult*, *deficiency*, and *expensive*. To illustrate, in the Need for Project examples below, **bolded** words signify drawbacks identified in previous work whereas <u>underlined</u> words indicate the transition from the preceding Background move to the Need for Project move.

7.4 <u>However</u>, the successful application of optical and spectroscopic methods in high temperature fluids at elevated pressure **requires** reliable window design that can typically withstand repeated thermal and pressure cycling. (Pr1_00_4)

7.5 A serious **problem** that **impedes** higher productivity and capital effectiveness is that the existing paper machines are dryer-limited. Currently improved productivity **can be achieved only at the expense** of high capital cost because new dryers are **expensive** and innovative retrofit technologies are **not available** yet. With increasing global competition, the industry **urgently needs** a dramatic breakthrough in drying technology to obtain an edge over foreign competitors. A higher drying or evaporation rate will reduce the number of dryers needed and/or raise dryer operating velocity, which means higher productivity and stronger competitiveness. So there is **a strong interest** in reducing capital and operating costs through enhanced heat transfer performance in the dryers. (Pr1_01_1)

7.6 Currently existing stroke robots were typically developed as laboratory research tools. In the early days of robotic therapy it was **unknown** what robot capabilities would be critical and which variables would be of the most interest. As a result, the robots were conservatively designed with power output, precision, and sensing capabilities **in excess of what is required** during therapy. Conservative designs had other secondary effects. The size and weight of the actuators made it **difficult to implement** additional degrees of freedom, **limiting** the complexity of robot-aided movements. The robots as a whole are **bulky, heavy, and difficult to transport**. And the robots are quite **expensive to make**. (Pr1_01_4)

7.7 It is common practice to use lasers for precision aiming of shaped charge jets. The laser aimers currently deployed **suffer from two operational deficiencies**: 1) The beam from the red diode lasers used in these aimers is **difficult to see** in some conditions, particularly in sunlight, and 2) They are attached to the shaped charge directly in line with the jet axis so they must be removed prior to firing the charge. Removal of the laser from the charge creates the possibility of accidental movement of the charge and **precludes the possibility of verifying charge alignment** immediately prior to firing the charge. (Pr1_07_3)

7.8 <u>However</u>, we **did not have** a predictive integrated computational capability to model in detail the relevant physics associated with any of these proposed applications. Consequently, **the goal of this LDRD project** was to develop the theoretical understanding and computational capability to guide current experiments at small-scale short-pulse laser facilities, and make credible predictions about the likely performance of high-energy short-pulse laser facilities currently under construction. (Pr2_07_1)

Unlike Swales' Establishing the Niche move, the Need for Project move is frequently realized by simply stating the project's objective(s) (**bolded** in 7.9–7.13) or indicating the interest of the project's sponsoring agency (<u>underlined</u> in 7.14–7.16). Further, both (a) the description of the previous design drawbacks and (b) an indication of the project's objectives and/or sponsoring agency can be found in the same realization of the Need for Project move (7.17).

7.9 We are proceeding with the development of a high-energy (10 MeV) neutron imaging system for use as an inspection tool in nuclear stockpile stewardship applications associated with the DOE Enhanced Surveillance Campaign (ESC). **Our goal is** to develop and deploy an imaging system capable of detecting cubic-mm-scale voids, cracks or other significant structural defects in heavily-shielded low-Z materials within nuclear device components. (Pr1_05_2)

7.10 **The objective of this contract is** to develop and demonstrate "cost effective" Composite Drill Pipe. It is projected that this drill pipe will weigh less than half of its steel counterpart. The resultant weight reduction will provide enabling technology that will increase the lateral distance that can be reached from an offshore drilling platform and the depth of water in which drilling and production operations can be carried out. (Pr1_06_1)

7.11 **The objectives of this grant are** to simulate and fabricate an optimized micromachined microjet array (MJA) impingement cooling device for high power electronics. A chip-scale microjet impingement cooling device will also be implemented with heat source fabricated on its target plate. (Pr2_04_4)

7.12 **The primary objective of this project is** to develop the Dust Particle Analyzer (DPA), a microdetector that is capable of performing real time, simultaneous measurements of the mass, the velocity and the electrostatic charge distributions of dust particles in the Martian aeolian process. (Pr3_03_1)

7.13 **The goal of this project is** to develop high efficiency thin Si solar cells as the low band gap bottom cell for high efficiency thin film tandem applications. This work supports the goals of the High Performance Program to achieve a 15% polycrystalline tandem cell by 2006. (Pr4_08_2)

7.14 In particular the <u>Air Force Research Laboratory is interested in</u> utilizing an FRC plasma as a propulsion concept. (Pr2_05_1)

7.15 <u>The Test and Engineering Directorate at NASA John C. Stennis Space Center (SSC) continues its efforts to</u> assemble a software simulation package that captures the static and dynamic characteristics of modern and future thermodynamic systems. The package is foreseen to fulfill the need for an accurate and verifiable thermodynamic system simulation. (Pr3_03_4)

7.16 **The program objective is** to create new optical sensors based on bio-inspired concepts and use them for sensing applications <u>of relevance to the United States Air Force</u> - from the detection of chem-/bio- warfare agents to sensing physical processes needed for the design of high performance jet aircraft. (Pr2_05_3)

7.17 To date, **however**, all of these robots are strictly teleoperated devices (i.e., remote-controlled) with **no onboard intelligence**, and thus **require intense operator involvement** and high-bandwidth communications links. To address these **shortcomings**, the <u>JRP Technology Transfer Project managed by SSC San Diego seeks to</u> enhance the functionality (ability to perform more tasks) and autonomy (with less human intervention) of these teleoperated systems. **The objective is** to expedite advancement of the technologies needed to produce an autonomous robot that can robustly perform in battlefield situations. (Pr2_06_1)

The third most frequent move found in the EDR Introduction unit is the Current Design move. In this move, professional EDR writers typically present a solution for a problem identified in the Need for Project move. Naturally, the Current Design move most frequently directly follows the Need for Project move and briefly describes the main features of the artifact that is being designed. Examples below demonstrate that frequently, in presenting solutions, EDR writers explain how the drawbacks in the previous designs are being addressed by the new design. References to these explanations are **bolded** in excerpts 7.18–7.23.

7.18 The laser aimer described in this report **addresses the first deficiency by** using low-cost doubled Nd:YAG (532nm) laser modules of the type used for green laser pointers. The responsivity of the human eye peaks near this wavelength, making light from these lasers much more visible for a given laser power, so that good visibility can be obtained with eye-safe Class 3a lasers. **The second deficiency is addressed by** using two laser modules mounted in the shaped charge holder, off-axis from the charge itself. (Pr1_07_3)

7.19 **In contrast**, the AMD has as many as seven degrees of freedom per arm, three at the shoulder, one at and elbow, and three at the wrist allowing it to assist a wide variety of complex, natural human arm motions. The low cost, ease of portability, and ability to facilitate complex movements gives the AMD a versatility **previously unachieved** in rehabilitation robotics. It will allow robotic therapy tools to reach more patients and to have a greater effect. (Pr1_04_1)

7.20 The S4 system **addresses these challenges** with a new storage management structure. The storage management system uses a log-structured object system for data versions, a novel journal-based structure for metadata versions, and an opportunistic on-disk anti-entropy cache for restoring sequentiality to version-scrambled objects. (Pr2_00_1)

7.21 **To this end**, the Network Enabled Resource Device (NERD) was created. NERDs are electronics boxes which contain six basic components: a RISC-based ipEngine processor with FPGA-based I/O, a wireless bridge and hub allowing point-to-multipoint communications, a VP500 audio/video hardware CODEC, an integral DC-DC converter for power, and the enclosure. (Pr2_02_3)

7.22 Our new fabrication technique **eliminates the above-mentioned limitation**. In our present work, we used three wafers to fabricate the piece parts for the MJA impingement cooling device. As such, we have only two bonded interfaces as shown in Figure 1 when compared to four bonded interfaces as in Leland's MJA devices. (Pr2_04_4)

7.23 **The disadvantage of non-uniform load distribution can be effectively reduced** by regulation of installment of planet gear as it is proposed in this report (fig. 6). (Pr3_04_4)

The principal function of the Current Design move, however, is to introduce the current design and describe its most important characteristics. This description of the designed artifacts can be rather brief (**bolded** in 7.24–7.25) or longer and accompanied by a few figures (**bolded** in 7.26–7.27). Like Swales' Occupying the Niche move, in which RA authors typically introduce new research, the Current Design move sometimes begins with a reference to the present report (<u>underlined</u> in 7.24–7.25). Excerpts 7.24–7.27 from the EDR Introduction unit's Current Design moves illustrate these trends.

7.24 <u>In this paper we present</u> **RF MEMS switches** which utilize 500- and 300-nm-thick amorphous SiC films for structural support in order to improve reliability. The MEMS switch incorporating the 500-nm-thick microbridge actuates readily but suffers from poor RF performance while the switch with the 300-nm-thick

SiC microbridge exhibits great RF performance but does not actuate reliably. (Pr3_08_4)

7.25 The current paper discusses the development of **a new test fixture to assess advanced seal concepts in simulated reentry heating conditions**. This test fixture will permit testing of a variety of seal sizes, shapes, and materials against a wide range of candidate advanced control surface designs and materials at near-operating temperatures and pressure drops. (Pr3_04_3)

7.26 **The REM** contains all of the functionality required for a 1.25-GHz (L-band) radar and can also serve as the back end for a higher-frequency radar system. The key functions of the REM include signal generation, frequency translation, amplification, detection, data handling, and radar control and timing. The REM drives the transmit/receive (T/R) modules located in the antenna and interfaces with the data storage system. The functional elements of the radar electronics module are shown in Fig. 1. (Pr3_04_7)

7.27 Figure 3 shows the **new ICS concept** proposed for Cazenovia Creek. It consists of evenly spaced cylindrical piers anchored in main channel and does not include a weir. The adjacent treed floodplain is left intact to act as a flow-bypass channel. In proposing this ICS, we expected that vertical piers spaced the same distance apart as the Hardwick ICS blocks would offer significantly better ice-retention capability, especially for thinner ice. (Pr5_00_1)

A less frequent the Project Summary move, in which professional EDR writers recount major accomplishments of the design project, tends to occur in the Introduction units with a relatively small number of moves. In fact, out of the 16 occurrences of the Project Summary move in the EDR Introduction unit, ten were observed in Introductions with four or fewer moves. This move also tends to occur in the Introduction units that do not contain the Current Design move; only four occurrences of the Project Summary move were found in EDRs where the Current Design move was present. This finding might be explained by the similar communicative purposes of the two moves; both the Current Design and the Project Summary moves report on the outcomes of the design project. However, whereas the Current Design move's focus is on the description of the most important characteristics of the designed artifact, the Project Summary move reports on the design activities that were carried out in the course of the design project and culminated in the creation of the artifact. This function of the Project Summary move seems to be somewhat similar to the statement announcing principal findings observed in physical science articles by Swales and Naijar (1987). Examples 7.28–7.30 demonstrate this shift in focus in the Project Summary move by detailing design teams' achievements. Note the reliance on activity verbs (**bolded**) and the use of passive voice (underlined).

7.28 A blade structural design code **was developed** in support of a project comparing two- and three-blade rotors for a hypothetical turbine. The code **generated** blade designs and their structural properties. Based on these properties, **we built** aeroelastic models of two- and three-blade rotors for comparative studies. The theory basis for the blade design code, which uses the classical laminate theory, has already been reported [1]. (Pr4_04_1)

7.29 The XCEM **was developed** under this project through contracts with CES (DACA42-00-P-0245 and DACA42-01-R-008). A prototype **was constructed** incorporating necessary improvements determined from the Butte testing, such as user friendliness, automation, and the capability to monitor mercury (Hg). This prototype **was then tested** in the laboratory by comparing it against the EPA Reference Method 29 (M29). A new monitor **was constructed and readied** for demonstration at the 1236 production deactivation furnace at Tooele Army Depot (TEAD), UT. (Pr5_05_1)

7.30 In this work, **we implemented** multi-scale fabrication techniques for the plates (or interconnects) that compose the outer layer of Proton Exchange, or Polymer Electrolyte, Membrane (PEM) fuel cells. These fabrication methods, including high-speed machining, photolithography, and micro-molding, encompass feature production from the nanometer to millimeter scales and were synergistic with thermal management research (J. Klausner), impedance spectroscopy characterization of fuel cell performance (M. Orazem), and computational fluid dynamics modeling work by enabling new geometries to be realized and studied. **We focused** on the anode and cathode current collection plates because they currently contain surface patterns and are critical to enhanced fuel cell operation. (Pr3_08_5)

The next two less frequently used but still relatively prominent moves of the EDR Introduction unit are the Previous Work and the Overview of the Report moves. It must be noted that at the onset of coding procedures, two individual moves labeled the Previous Work by Others and the Previous Work by Authors were used instead of the Previous Work move. However, often previous work was described in a rather compressed way, making it difficult to identify who carried it out. Moreover, because members of engineering teams can change over time, even when the move contained in-text citations, sometimes it was utterly impossible to determine whether previous work was performed by the EDR writers or someone else. Therefore, the move label was modified, and the whole corpus was recoded with the new label that combined both types of previous work.

The Previous Work move is often found after the Need for Project move. It typically occurs in longer Introduction units and describes previous attempts (typically not by the EDR authors but someone else) to solve a specific problem mentioned in the Need for Project move. Examples 7.31–7.32 demonstrate that the Previous Work move is used by EDR writers to identify drawbacks of previous designs (**bolded**). This function of the move is somewhat similar to that of the Need for Project move. However, unlike the more general identification of the need in the Need for Project, the Previous Work move refers to specific organizations and people and, thus, includes names, references, places, and dates (underlined).

7.31 This approach was originally tested in 1997 at an EPA test incinerator, where the filters were analyzed offline (French 1998). Cooper Environmental Services (CES) further developed this method into an online system tested under the ERDC/CERL Waste Minimization and Pollution Prevention Program at MSE Technology Applications, Inc.'s (MSE-TA's) research incinerator in Butte, MT (Bryson et al. 2000). The results were encouraging because the XCEM met the PS-10 RA requirements for chromium (Cr) and lead (Pb). **Many of the other requirements were unmet, however, and further development was needed**. It was at this point that ERDC/CERL began funding the development of XCEM technology under their Hazardous Air Pollutants (HAP) program. Table 1 lists the Army's 19 existing, new, or planned hazardous waste combustors (Josephson 2003). (Pr5_05_1)

7.32 Linear models of Stirling convertor systems, including a dual-opposed system and a single convertor system with a balancer were analyzed in detail as part of NASA GRC's Stirling convertor modeling effort. The models reported in the literature have included only the mechanical and mounting dynamics. The pressure wave was modeled by constants—called pressure factors—that were calculated by SDM to represent the pressure are at the point at which the model was linearized. The models described in Ref. 1 **were not equipped to track the relationship** between output power, hot-end temperature and piston amplitude. (Pr3_07_2)

Further, instead of pinpointing drawbacks of previous design attempts, the Previous Work move is also used by EDR writers to provide necessary information about the current design project, sometimes discussing its historical development, specifically providing an account of its major contributors. In most cases (see 7.33–7.34), this description involves the identification of EDR writers' home organization(s) (underlined) and acknowledgements of past projects' major achievements (**bolded**).

7.33 In 1997, ANL **successfully developed a top-ranked MD project** in the energy performance category of the American Forest and Paper Association's Vision 2020 Initiative. The project was funded for two years (FY 1998 - 1999) by the DOE Office of Industrial Technologies and with in-kind cost share by the two industrial partners, Eastern Paper and The Johnson Corporation. Phase 1 of the MD Project has been conducted by an R&D team from ANL, the University of Illinois at Chicago, The Johnson Corporation, and Eastern Pulp and Paper. This final report shows that Phase 1 of the MD Project **successfully demonstrated the feasibility of the concept** of an MD. (Pr1_01_1)

7.34 NASA Langley Research Center has taken **a leading role in developing instrumentation** to pursue these longer wavelength measurements. **A stepping stone has been the development** of the Far-Infrared Spectroscopy of the Troposphere (FIRST) instrument for balloon-borne measurements to 100 µm in the far-infrared. (Pr3_07_1)

The Overview of the Report move, which typically occurs at the very end of the EDR Introduction unit, is meant to orient the reader to the structure of the entire design report. This move frequently starts with a reference to the EDR (**bolded** in 7.35–7.40) and is typically rather brief, contained within a sentence or two (7.35–7.39). Sometime, however, EDR writers feel that it is necessary to describe each EDR organizational unit in more detail, leading them to write longer Overview moves (7.40).

7.35 **This report discusses** the efforts associated with the development of a DWD system capable of sustained operation at 225 °C. **(**Pr1_09_1)

7.36 **This paper describes** self-securing storage and our implementation of a self-securing storage system, called S4. (Pr2_00_1)

7.37 **This report describes** the design, operation, and validation of the DADD. (Pr2_08_1)

7.38 **In this article**, the design and results of the first component developed, the L-band transceiver, are presented. (Pr3_04_7)

7.39 **This report describes** blade structural layout, a summary of the theory basis, and the steps required for code usage. Finally, we describe the code-generated composite blade designs used in the comparative study. (Pr4_04_1)

7.40 **The remainder of this paper is organized as follows**. Section 2 discusses intrusion survival and recovery difficulties in greater detail. Section 3 describes how self-securing storage addresses these issues, presents some challenges inherent to self-securing storage, and discusses design solutions for addressing them. Section 4 describes the implementation of S4. Section 5 evaluates the S4 implementation. Section 6 discusses a number of open issues related to self-securing storage. Section 7 discusses related work. Section 8 summarizes this paper's contributions. (Pr2_00_1)

7.2.2.3. Move Sequence Analysis

Table 7.4 shows the sequence of the most frequent moves in the Introduction unit. The results of the analysis indicate that commonly professional EDRs begin with background information about the design project. In fact, 33 professional EDRs in the corpus (42.86%) began with the Background move, followed by the Need for Project move whereas the reverse sequence (i.e., Need for Project – Background) was found in only 6 EDRs (7.79%). Frequently, professional EDRs also include a description of the current design, which typically concludes the Introduction unit or appears close to this unit's end. The Current Design move was observed in the Introduction unit of 37 professional EDRs (48.05% of the corpus), concluding this unit in 17 reports (22.08%). The only other move that was found frequently to either conclude or appear close to the Introduction's end was the Overview of the Report move, which occurred at or close to the end of the Introduction organizational unit in 16 EDRs (20.78%).

Congruent with the results of previous research (Crookes, 1986; Swales & Najjar, 1987), the results of the present study demonstrate that the Background – Need for Project – Current Design move pattern tends to be commonly used in the EDR Introduction unit. However, the longer the Introduction unit, the more deviations and move cycles are observed. In fact, in cases where the Current Design move did not immediately follow the Need for Project move, the next move slot was most frequently occupied by either an additional Background move or a Previous Work move. The Project Summary move occurred mostly toward the end of the Introduction units with fewer than four moves and mainly in those EDRs that did not contain the Current Design move. Other moves identified in the Introduction unit and included in Table 7.4 (e.g., Evaluation, Requirements and Constraints, and Specifications) were relatively infrequent (see Appendix K for their description and examples).

Table 7.4 Most frequent Introduction moves by move slots

Move	Move slot number									
	1	2	3	4	5	6	7	8	9	10
Background	**42**	***8***	***12***	**8**	***5***	***3***	**3**	**2**		
Current design	2	5	**14**	*7*	**7**	**4**	***2***		**2**	
Description of Materials (DOM) functional									1	
Description of Materials (DOM) physical								1		
Evaluation				1						
Follow-up activities						1	1		1	
Need for project	***22***	**36**	7	**8**	4	**4**		1		
Overview of the report		4	5	5	4	2	**3**			
Planning and project management		4	2							
Previous work	2	4	**14**	**8**	**7**	2	1	1	1	
Procedures				2						**1**
Project summary	3	6	2	2		1	1	1		
Requirements and constraints	1	5	2	3	2	1				**1**
Results					1					
Section blurb	5				1					
Specifications			1							

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Based on the results of the analysis, it appears that although many patterns have been observed in the EDR Introduction units of professional EDRs, commonly professional EDRs contain the Background, Need for Project and Current Design moves, each occurring in approximately 50% or more of the EDR Introduction units of the corpus (see Table 7.2). These moves seem to be the core, and thus crucial, moves of the unit. Another move that was included in the model as an optional move of the unit is the Previous Work move, found in more than 40% of all Introduction units of the professional EDR corpus. Other less frequent moves of the Introduction unit, such as the Section Blurb, Project Summary, and Overview of the Report moves, were not included in the model. The model below illustrates these findings and sequence (read from left to right) of the Introduction unit moves, with the optional move in parentheses.

Table 7.5 Proposed Introduction unit model

Introduction unit model			
Background	Need for Project	(Previous Work)	Current Design

Note: parentheses indicate optional move(s)

7.2.3 Methods

The primary purpose of the EDR Methods unit is to detail design procedures used in the course of the project. Previous research on RA Methods sections has not been as productive as studies of RA Introductions. A few studies that have examined the RA Methods section reported its much more flexible rhetorical organization, often with no distinct patterns, when compared to the relatively linear development of the move sequence in RA Introductions (Kanoksilapatham, 2005; Skelton, 1997). This flexibility has been largely attributed to the content-driven nature of the Methods section, which is heavily influenced by distinct disciplinary practices. Previous research on RA Methods sections also reported that this section tends to consist of two main components, materials and procedures, which interact in two different ways (Weissburg & Buker, 1990). That is, in some Methods sections, materials are described separately in a subsection of their own whereas in other articles materials are described in an integrated manner simultaneously with the procedure for each step of the study.

The results of the analysis of the EDR Methods unit seem to corroborate previous findings in that this unit shows much more flexible move sequences compared with the Introduction unit. However, when describing design methodologies, EDR writers typically discuss procedures and materials at the same time, alternating these descriptions as they deem appropriate. The results of the EDR Methods unit analysis also suggest that only the description of procedures can be considered a true obligatory move in this unit. Common moves of the Methods unit are discussed below in detail and illustrated with several examples from the professional EDR corpus. Other, less frequent moves identified in the Methods unit can be found in Appendix K. Before the moves are discussed, the results of the move frequency analysis are presented.

7.2.3.1. Move Frequency Analysis

Of the 80 EDRs in the corpus, 37 did not include the Methods unit; instead, they had a merged Methods and Results unit. In addition, three EDRs did not have either a Methods or a Methods and Results unit because, most likely, all three reported on work that had been previously discussed elsewhere. Therefore, 40 EDRs were considered for the analysis in this section. Table 7.6 shows the frequency of moves in the stand-alone Methods organizational unit. Only moves found in more than 20% of the corpus EDRs are included in this table. All other, less frequently used moves, can be found in Table 7.6, which displays all Methods unit moves by move slots. As expected, the move used by professional EDR writers most frequently is Procedures, used in all but five EDRs with the Methods unit. The five remaining EDRs instead focused on the description of the artifact's functions. The second and third most frequent moves of the Methods unit are the Description of Materials moves (DOM Physical and Functional), in which EDR writers describe what design artifacts look like, what they consist of, and how they function. In addition, the Methods organizational unit may include Background, Current Design, Results, and Testing Procedures moves. Further, the Methods unit quite frequently begins with the Section Blurb move.

Table 7.6 Frequent moves of the EDR Methods unit

Move	Number of EDRs with the move (n=40)	Percentage of EDRs with the move (%)
Procedures	35	87.50
Description of Materials (DOM) physical	18	45.00
Description of Materials (DOM) functional	16	40.00
Background	16	40.00
Current design	14	35.00
Section blurb	14	35.00
Results	13	32.50
Testing procedures	12	30.00
Requirements and constraints	11	27.50
Optimization and troubleshooting	9	22.50
Problems encountered	9	22.50

7.2.3.2. Frequent Moves of the Methods Unit

The most common move of the Methods organizational unit, the Procedures move, describes design methods (i.e., procedures and instrumentation used in the design project). The procedures described could be design procedures (e.g., steps taken to create an artifact) or analytical procedures (e.g., decision making procedures that involve alternative design considerations). Common equipment is typically only briefly identified while custom-built or special equipment may be described in more detail. Examples below illustrate the Procedures moves describing design (7.41–7.43) and analytical procedures (7.44–7.46), with verbs describing procedures **bolded** and references to equipment underlined. Note that examples 7.45–7.46 describe both types of procedures.

7.41 After formation of the droplet at the tee junction, it **was convected** into the flow cell. The position of the droplet **was visualized** with a pair of monochrome cameras (Watec LCL-902C), focused along the flow axis of symmetry and oriented at 90º, as shown in Figure 7. The video output from these cameras **was read** into a computer using two frame grabber cards (NI-1409 and NI-1407, from National Instruments, Austin, TX). The images from these two cameras **were analyzed** in real time at a rate of approximately 2 frames per second to determine the drop location. (Pr1_06_4)

7.42 In the EKF model, we **use** the local tangent plane (LTP) coordinates that represent our world as being locally flat and **simplify** altitude and local-direction representation for a vehicle. (Pr2_06_1)

7.43 Once the base layers of imagery **were established**, subsurface features such as faults, geologic strata variances as documented at the time of construction, dam-foundation features, etc., **were added** to form the third dimension (subsurface). Existing paper cross sections **were digitized and rectified**, such that their relationships to each other could be established. (Pr5_07_1)

7.44 Due to the conical geometry of the v-band's contact surfaces (the angled ramp in three dimensions is in fact a cone), an analysis of the system by conventional manual means appeared to be complex and problematic. A further consideration was that since a major design goal was to find an optimum configuration with minimal material, an iterative design and analysis process would be required. It was therefore **determined** that a numerical analysis using available Finite Element Analysis (FEA) tools would be advantageous, enabling exploration of a range of solutions in a relatively short time. (Pr1_02_1)

7.45 We **eliminated** Gerotor pumps as **we deemed** them more complex to fabricate and operate and they provided no performance advantages. **We deemed** the extra complexity as making it more susceptible to failure from contamination, which is possible in a biological system such as a space suit. We **eliminated** screw/roots type pumps as they are more suitable for larger applications than this one, and are complex and expensive to fabricate. Various types of diaphragm pumps **were eliminated** due to their creation of high pressure pulses and concerns over diaphragm fatigue failures. Other types of pumps, such as reciprocating pumps and scroll pumps, **were dismissed** due to their complexity and cost for this application. (Pr3_10_2)

7.46 To meet the engine requirements, the Pulse system by B&K **was selected** as the hardware platform. The Production Test Advisor (PTA) by Signalysis, Inc. **was selected** as the database management system. MATLAB (The MathWorks, Inc.) based post-processing system **was developed** in-house at GE and **integrated** into the system for real-time health monitoring. A brief system diagram is shown in figure 3. (Pr3_06_3)

Another common move of the Methods unit, the Physical Description of Materials (DOM Physical) move, describes items or components used in the design project. When the final design consists of multiple components, these components tend to be discussed in separate subsections with headings setting one subsection from another. The DOM Physical move typically describes what a particular design component looks like or what it consists of. Note the verbs (**bolded**) used to define the design components and describe their main characteristics (e.g., size, location, and materials) in the following examples of DOM Physical move.

7.47 The sub **is** a tubular tool, 7" in diameter by approximately 85" long, with a central electronics/sensor package suspended by three-legged supports inside the structural housing (see Figure 1). The metal parts of the tool **are made from** non-magnetic materials to allow proper magnetometer operation, and the structural case **is sized** for the loads typical in drilling 8-1 /2" hole. (Pr1_03_1)

7.48 Currently, the main processor used in the NERD **is** the ipEngine **made** by BrightStar Engineering. The ipEngine **is based on** Motorola's PowerPC MPC823 processor. It **offers** a 50MHz processor, 16MB DRAM, 4MB Flash memory, 10Base-T Ethernet, 16W power output, 16,000 gate FPGA, 132 pin virtual I/O interface, USB host/slave controller, LCD/Video controller and dual RS-232 ports. The ipEngine **draws** a maximum of 250mA at 12VDC. (Pr2_02_3)

7.49 The ECMP **consists of** a power supply and feed-back system, a power distribution/wire harness assembly, sample holders, a chemical bath, and a vibrating base plate system. (Pr2_10_1)

7.50 Controls Board **is located in** Card Cage Slot 4. Its primary role **is** to house eight custom circuits which include LED variable lighting, chamber mixing fan control, smoke wire controls, a 15 V power supply for the 120 V isolation amp, 02 sensor variable controlled (12 to 6.25 V) power supply, tunnel air flow blower control, ±12 V 02 sensors power supply, and substrate heater control circuits. (Pr3_06_5)

7.51 The starting material for silicon or germanium BIB detectors **consists of** layers of single crystal silicon or germanium, with the principal detector layer being doped with a Group III or Group IV species to make it responsive to infrared wavelengths. Table II lists the relevant material parameters of the infrared active layers for the starting material for the pilot lot. (Pr3_07_1)

The DOM Physical move most commonly follows the Procedures move. In fact, 12 out of 36 occurrences (33.33%) of the DOM Physical move in the Methods unit follow this pattern. Professional EDR writers also tend to use the DOM Physical move immediately before functional descriptions of the same components (i.e., the DOM Functional move described below). Excerpt 7.52 illustrates the Procedures – DOM Physical –DOM Functional move pattern; superscript identifiers are inserted to show the move boundaries. The DOM Physical move is *italicized*; the DOM Functional move is **bolded**. Note the use of verbs in all three moves (underlined), with verbs describing activities carried out by the engineering team in the Procedures move, verbs describing physical characteristics of a particular design component in the DOM Physical move, and a verb showing the component's functionality in the DOM Functional move. The report then continues with the description of functional capabilities of individual smaller design components, each realized with the DOM Functional move and described in a separate subsection under a separate subheading.

7.52 (Procedures) In response to this recommendation, the XCEM has been fully automated using a WonderWare® software interface. (DOM Physical) *This interface includes a variety of screens that allow the user to control components, diagnose problems, view concentration trends, and output data. Each screen contains an alarm signal in the lower right-hand corner that flashes if some component of the system is not working or if the metals' concentrations exceed user-defined limits. The XCEM interface is password protected and can be accessed by either an operator with limited XCEM control or an administrator with full user rights.* (DOM Functional) **The computer interface allows the user to view a number of screens that present operational data for control of the XCEM. Those screens are presented below.** (Pr5_05_1)

The EDR excerpt above also demonstrates the difference between the two DOM moves. Specifically, while the DOM Physical move's focus is on the physical characteristics of the design component(s), the DOM Functional move describes components' functional characteristics, or details about how these components work. Note how the present tense verbs and modal verbs (**bolded**) are used in examples 7.53–7.54 to describe typical functions of design components.

7.53 The anti-entropy cache **keeps** a sequential copy of an object's direct blocks (up to

60KB) along with the object's onode and ACL table in a special segment. When a read request **is made**, the entire anti-entropy cache **can be read**, **retrieving** the object's metadata along with the stored data in one, quick operation. Because of their limited size, they currently **have little effect** on large files, but smaller, rapidly changing files **can have** improved read performance over other log-structured file systems. (Pr2_00_01)

7.54 The pump **uses** a direct shaft to the motor rotor, so no in-line magnetic coupling **is used** to maintain fluid sealing. A stationary fluid barrier **encases** the entire pump cartridge and rotor shaft, **segregating** the working fluid from the stator and Hall Effect sensors. The stationary fluid barrier **terminates** at the motor end of the assembly using an o-ring seal between the OD of the barrier and the ID of motor housing bore (bore seal). This approach **provides** semi-hermetic sealing of the working fluid. Magnetic coupling **links** the stator to the rotor; as in a typical motor, only the magnetic flux **passes** through the thin metallic fluid barrier. (Pr3_10_2)

The Background move in the Methods unit serve a very similar function to the Background move in the Introduction unit in that they both provide pertinent information needed for understanding the design project. In the Methods unit, however, this pertinent information revolves around specific procedures used in the course of the project. In fact, out of 25 occurrences of the Background move in the Methods unit, 16 instances (64%) were found immediately preceding the Procedures move, indicating that here the Background move provides necessary information about specific design activities or instrumentation. Note the common use of the present tense (**bolded**) and modal verbs (<u>underlined</u>) in Background examples 7.55–7.58.

7.55 As with most engineering design, optical engineering (OE) **is done** with intuition and some computer support. Lens design codes **are** quite mature. They <u>can</u> quickly find the optimal design in the design space specified using (i.e.) a damped least-squares criteria. The code used most frequently here at Sandia **is** "Zemax". It **allows** one to optimize aspheric surfaces, cylindrical and other surfaces of rotation, diffractive elements, tilts and displacements in the presence of constraints on first-order optical properties, lengths, shape constraints, multiple wavelengths, multi-configurations (like zoom lenses), and more. (Pr1_07_1)

7.56 In answering the above questions of interest, the first two in the list necessarily **make** the analysis process an iterative one. After determining the absolute minimum ramp angle to ensure the v-band <u>will</u> release properly, one <u>must</u> then calculate the forces required for equilibrium without violating the maximum force on the bolt, apply them to the model, and then determine if the v-band material **is** subject to stress failure. If not, the model's stress plot **is examined** to determine where 'excess' material **exists** and the model **is** then **'trimmed'** to remove it. This **results** in a change in the flexible characteristics of the model. Consequently, a new set of forces must be determined for equilibrium and the process **repeats**. This sequence **is followed** until a point **is reached** where one of the conditions fail. In general (for v-bands), while a larger ramp angle, a, **reduces** the chances of self-locking, it simultaneously **increases** the radial component of the imposed forces and **results** in increased force on the spreader bolt. Thinning of the v-band cross section **tends to reduce** the forces that resist the bolt's work of expanding the v-band into the installed position, thereby reducing the magnitude of the radial components in the force system. (Pr1_02_1)

7.57 The EKF **is** a state observer that **relies** heavily upon the measurement of related states to produce an accurate estimate of the system state. If too few sensors **are used**, the resulting state estimate will diverge because the system **is** unobservable. Also, if the state and sensor noise variances **are not** accurately **modeled**, the EKF will not properly filter the common noise associated with each sensor, and the state estimation will further diverge from the actual state. The key states that **need to be measured** for our particular implementation **are**: velocity, pitch, roll, and yaw rate. By measuring these four states, an accurate depiction of the robot's pose can be generated. However, using more sensors and measuring more states will create a more accurate state estimate. (Pr2_06_1)

7.58 Fuzzy Logic **provides** a framework to compute a control output for many complex processes for which human operators **seem** to develop an intuitive feel for successful manual control that cannot be duplicated by traditional automatic feedback loops (such as PID). The basis for a Fuzzy controller **is** a set of rules developed in consultation with experienced operators. The rules **represent** the knowledge of the operator and capture the manual control response to various input scenarios, converting that knowledge to code that can run automatically. (Pr3_03_3)

7.2.3.3. Move Sequence Analysis

Table 7.8 shows the sequence of the most frequent moves in the Methods unit. As the table demonstrates, the Methods unit shows much greater flexibility in its move sequences, as compared to the Introduction unit, and longer Methods units show the most variation. This finding is consistent with the results of previous research (Kanoksilapatham, 2005) and is likely to be attributed to the content-driven nature of the Methods unit, in which a variety of designs can be described, resulting in different move sequence patterns. Nevertheless, the move sequence patterns that emerge seem to show preferences for describing design procedures and materials in the first half of the Methods unit.

To detail design activities, the Methods unit heavily relies on the Procedures move, which occurs throughout the unit. Table 7.8 may give an impression that the procedures move is used most frequently in the beginning of the unit; however, this first impression finds little support when all move sequences are examined closer. This inconsistency is due to the fact that both short and longer Methods units begin with the Procedures move whereas only longer units continue to use it in subsequent move slots. Although the Procedures move is the most frequent move of the unit, other moves are used to support and extend it. As can be seen from the emerging sequence patterns, Procedures moves frequently alternate with four other moves: Physical Description of Materials (DOM Physical), Functional Description of Materials (DOM Functional), Testing Procedures, and Results.

The two DOM moves and the Procedures move are so closely interwoven that it might not seem reasonable to assume that one move precedes the other. Upon a closer examination, however, it appears that most EDR writers begin the Methods unit with the Procedures move and then proceed to the Description of Materials (physical and functional). In fact, only one EDR in the corpus included the DOM Physical move as the first move of the unit. On the other hand, ten EDRs (25%) started this unit with the Procedures move. Even when the first move slot is occupied by other moves, such as the Section Blurb, Current Design or Background, the second move slot is most commonly occupied by the Procedures move. In such EDRs, the second move slot tends to be occupied by the Procedures move, which then is alternated with one of the DOM moves.

The results of the analysis also demonstrate that professional EDR writers use slightly more DOM Functional than DOM Physical moves, indicating practicing engineers' preference for describing how specific design components function. Furthermore, in six EDRs (15% of EDRs containing the Methods unit), DOM moves followed one another, with DOM Physical moves typically starting these sequences.

Longer Methods units appear to have more flexible move order, in which Procedures and DOM moves also alternate with Testing Procedures and Results Moves. Although alternating Procedures and Results moves typically would be expected in merged Methods and Results units (described in Section 7.2.5), the results of the analysis show that even when the main focus of the unit is on the discussion of design procedures, results tend to be reported, which is especially true for longer Methods units.

Other relatively frequent moves of the Methods unit, such as Current Design, Background, and Section Blurb, seem to occur most frequently in the beginning of the unit. In fact, out of 15 occurrences of the Current Design move in the Methods unit, 11 (73.33%) were observed in the first four move slots of the unit. This is not surprising considering that the Current Design move describes the complete designed artifact. In the Methods unit, this description, if present, generally precedes the description of the procedures and is included at the very beginning of the unit. The Background move, if present, also tends to immediately precede the Procedures move and, though it tends to occur most frequently in the beginning of the unit, it can be found throughout the unit together with the Procedures move. The Section Blurb generally introduces the whole Methods unit and most frequently opens it. However, because the Methods unit may include several subsections, each of which may have its own Section Blurb, this move has been observed throughout the unit. Other moves identified in Methods units and included in Table 7.8 were relatively infrequent.

Based on the findings reported in this subsection, it appears that the Methods unit consists of one obligatory move – the Procedures. In fact, two EDRs in the corpus included only this move and two more reports consisted of this move preceded by the Background move. Other frequent, yet optional moves included in the Methods unit model are the Background, DOM Physical, and DOM Functional moves, each occurring in at least 40% of the EDR Methods units. In the unit's move model (read from left to right) in Table 7.8, these optional moves are presented in parentheses.

Table 7.7 Proposed Methods unit model

Methods unit model			
(Background)	Procedures	(DOM Physical)	(DOM Functional)

Note: parentheses indicate optional move(s)

Table 7.8 Most frequent Methods moves by move slots

Move	Move slot number																													
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31
Assumptions					1		1				1																				
Background	6	***5***	2	2	1	1	2	1	1		1		1		1											**1**					
Current design	3	3		***5***	1	1			1							1															
DOM functional		4	***5***		***4***	***4***	***3***	***2***	**4**	***2***	***2***	**3**	**4**	**2**	**2**	1	**1**		**1**			**1**			1				**1**		**1**
DOM physical	1	3	4	4	3	2	***3***	**4**		1	1	**3**		**2**	1		**1**		**1**		**1**									**1**	
Follow-up activities				2	1			1		1														**1**							
Need for project	3		1																												
Optimization and troubleshooting		1	1	1	1	2		1		1			1		1		**1**				**1**										
Potential problems		1	1		1			1								1				**1**											
Previous work	1	1	1	1			1																	**1**							
Problems encountered				2	1		1		1		1	***2***		1																	
Procedures	**12**	**7**	**13**	**10**	**7**	**9**	**6**	**4**	**4**	**4**	**4**	1	***2***	**2**	**2**	**2**		**1**		**1**			**1**	**1**	**2**		**1**	**1**			
Project summary	1																														
Testing equipment	1																			**1**						**1**					
Testing procedures	1	3		2		2		***2***	1	***2***				**2**				**1**				**1**						**1**			
Recommendations					1					1									**1**												
Requirements and constraints	4	3							***2***	1		***2***																			
Results		2	1	2	3	2	***3***	1	***2***		***2***		***2***		**2**		**1**	**1**			**1**	**1**	**1**				**1**		**1**		
Section blurb	***7***	2	3		1			***2***		***2***				1		1							**1**								
Specifications		1			1																										

Note: A shaded cell represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

7.2.4 Results

The purpose of the EDR Results organizational unit is to report results of the design project. As such, this unit typically reports both testing procedures and their outcomes. While it is generally assumed that in scientific writing Results sections serve to present findings without interpretation, previous studies found that academic and professional writers frequently comment on their results within this section (Brett, 1994; Stoller & Robinson, 2013; Weissburg & Buker, 1990; Williams, 1999). The same observations have been made in the present study. However, because of the exploratory nature of this dissertation research, no attempts have been made during EDR coding to differentiate the objective reports of the findings and EDR writers' interpretations of the obtained results. Further, to highlight important features of project outcomes, EDR writers frequently rely not only on text but also on the accompanying graphics (i.e., tables and figures), constantly guiding the reader's attention with pointers such as *Figure 1*, *shown in*, and *(see Table 3)*. The paragraphs below present the move frequency analysis and describe common moves of the Results unit. The move sequence analysis then concludes the Results unit discussion. Infrequent moves identified in the Results unit but not discussed here can be found in Appendix K.

7.2.4.1. Move Frequency Analysis

Out of 80 professional EDRs, 36 included a merged Methods and Results unit, nine contained a merged Results and Discussion unit, and one included both merged units [MR] and [RD]. These 46 EDRs have been excluded from this discussion. Therefore, the frequency counts in this subsection are based on remaining 34 professional EDRs that included stand-alone Results units. Table 7.9 shows the frequency of the most often used moves in the Results unit. As can be seen, the Results move, which both reports and interprets the outcomes of the design project, is the most predominant move of the unit. This move was observed in all but one professional EDR in the corpus. The one EDR that did not contain the Results move within the Results unit instead described the outcomes of the design project using the Current Design move. The specific results and problems encountered were then reported in the Discussion unit of this particular EDR.

Table 7.9 Frequent moves of the EDR Results unit

Move	Number of EDRs with the move (n=34)	Percentage of EDRs with the move (%)
Results	33	97.06
Testing procedures	27	79.41
Problems encountered	22	64.71
Optimization and troubleshooting	18	52.94
Background	10	29.41
Procedures	7	20.59
Section blurb	7	20.59

Table 7.9 further highlights that in addition to reporting and commenting on the outcomes of the design project by using the Results move, EDR writers frequently (a) describe testing procedures used to obtain information on the design outcomes (Testing Procedures move), (b) pinpoint problems encountered during design and testing procedures (Problems Encountered move), and (c) report troubleshooting and optimization efforts (Optimization and Troubleshooting move). Other moves that occurred relatively frequently in the Results unit of professional EDRs are the Background, Procedures, and Section Blurb moves. Additional moves, listed in Table 7.10, occurred relatively infrequently.

7.2.4.2. Frequent Moves of the Results Unit

Because of the very general level of coding in this study, the most prominent move of the unit, the Results move, both objectively reports on the outcomes of the design project and its stages as well as interprets these results. Frequently, the Results move immediately follows the Testing Procedures move (described below) and reports on the results of a particular test. In addition, EDR writers tend to support information in the Results move with a visual (i.e., a table or a figure), and many Results moves begin with a "pointer" helping the reader locate that visual. Examples 7.59–7.62 illustrate this tendency, with "pointers" **bolded**.

7.59 Test results are an average of three replicate tests and **are shown in Tables 8 and 9** for the CSHVR and OCTA test schedules respectively. The same emission measurements **are presented graphically in Figures 9 through 12**. **These figures also show** the maximum and minimum emission values and indicate excellent repeatability for NOx and hydrocarbons. Repeatability for PM and CO is not as good because of the extremely low values measured (Pr4_05_1)

7.60 XCEM and M29 concentrations for the four M29 test runs **are shown in Table 6**. Reported concentrations for the two methods are in good agreement for all elements except Ag. No apparent overall bias is evident between the two methods. Indeed, the overall average non-Ag metal concentrations reported by the two methods are within a few percent of each other. This trend holds true for each sample run (**Table 7**) and indicates that it is probable that no particulate loss occurred in the sampling system. (Pr5_05_1)

7.61 We present results for blade B2 first. **Table 4a shows** the computer-generated output for the case in which only the double-bias material is used for root reinforcement. **Table 4b shows** the output assuming the use of unidirectional-material root reinforcement. **The top parts of the two tables show** the variation of blade mass, inertia, stiffness, elastic center offset, and mass-centroid offset with respect to the blade span. **The bottom parts of the tables provide** a weight breakdown of the different materials used in the blade design. The mass of the bolt inserts, though shown in the weight breakdown, is not included in section mass distribution. The inserts behave more like a concentrated mass at the discreet root location rather than a distributed mass reflected in the tables. Note that the total blade mass is about the same whether unidirectional- or double-bias material is used for root reinforcement because the two materials have about the same mass density. (Pr4_04_1)

7.62 **Table 5 shows** the power consumption as a function of inlet water temperature and flow rate. Based on our analysis, the contamination of the pump, represented by the time operated, had the largest effect on power consumption. The pump met its design goal of 15 W at nominal conditions by a wide margin. (Pr3_10_2)

When reporting results, professional engineers tend to not only signal the visual and report the outcomes of their work, but they also highlight the most crucial information presented on the visual. Quite frequently, EDR writers directly point the reader to the details important for the interpretation of the visual and the results overall. Examples 7.63–7.66 illustrate this with the use of the verb *note* (**bolded**) in the Results moves; the pointers are underlined.

7.63 Figure 5 shows the results of the correlation as a contour plot that is maximum at the target position (X1, Z1) = (2.5 m, 5 m). The 6-dB points on the PSF are 2.5 cm in the X direction and 0.52 m in the Z direction. Figure 6 shows the PSF for three targets at (X1, Z1) = (2 m, 2 m), (X1, Z1) = (2.5 m, 5 m), and (X1, Z1) = (3 m, 7 m). **Note that** the resolution in X is roughly constant in Z, but the Z resolution becomes lower with increases in Z. (Pr2_08_2)

7.64 These results are presented graphically in Figure 9, which has ROP calculated over somewhat shorter intervals and therefore gives better resolution. The figure shows that for much of the 1420–1481 ft interval, WOB was lower in Phase 2 than in Phase 1, but it is also useful to gain some insight to drilling efficiency by normalizing ROP relative to WOB and rotary speed. Figure 10 presents plots of ROP divided by the product of WOB and rotary speed. This figure clarifies the point that, in the 1420–1481 ft interval, the bit in Phase 2 drilled less efficiently than in Phase I. **It should also be noted that** the WOB values used in Figures 9 and 10 are downhole measurements, and that the figures imply, at fairly coarse resolution, the relative magnitudes of rock strengths through the drilled intervals. (Pr1_03_1)

7.65 Figure 11 and Figure 12 show the first two vibration modes and natural frequencies of the v-band. **Note** the first and second modal frequencies differ only by -3%, and the third mode was found to occur at approximately 217Hz, a result far enough removed from the first two modes as to render it not significant as a source of concern. (Pr1_02_1)

7.66 Of the structures within the Cazenovia Creek valley (Table 3), only Kotecki Grove and the Leydecker House are affected by ice jams at the ICS. **Note also that** ice jams at the ICS do not contact the bridge at Leydecker Road (low-steel elevation 666.00 ft). (Pr5_00_1)

The move that frequently precedes the Results move is the Testing Procedures move, in which the components of the design or the complete design are critically evaluated according to specific predetermined requirements. This move alternates with the Results move throughout the Results unit. In fact, 78.43% of the Testing Procedures move's occurrences in the Results unit happen before the Results move. Examples 7.67–7.69 illustrate these sequences, with Result moves in italics.

7.67 Crystallization of ~1.5 µm a-Si films by pulsed RTP was studied on samples deposited by hot-wire CVD (HWCVD), DC-PECVD, and electron beam (EB) evaporation. Deposition temperatures were 250°C for HWCVD, 300°C for PECVD, and <50°C for EB. Samples deposited by HWCVD and PECVD were annealed in N2 for 1 hour at 400°, 500°C, and 580°C in a tube furnace to drive hydrogen out of the films. Then each sample was subjected to a pulsed RTP treatment that consisted of pre-heating the at 550°C for 60s, followed by a fast ramp up to 800 or 850°C for 1 s and rapid cool down to 550°C. This cycle was repeated for a total of 2, 4 or 10 cycles to enhance grain growth. Crystallization of the a-Si films was observed by Raman spectroscopy (785 nm laser) and crystallite size was determined by X-ray diffraction. *Figure 2-1 shows the Raman spectra for ~1.5 µm thick Si films deposited by HWCVD on 1735 glass after deposition, after dehydrogenation, and after two cycles of pulsed RTP with a peak temperature of 800°C. The data shows broad peaks for the as-deposited film and the film after de-hydrogenation alone indicating the presence of an a-Si phase. However, after pulsed RTP a sharp Raman peak centered at about 521 cm-1 appears indicating that crystallization has occurred after only 2 cycles of pulsed RTP. Figure 2 shows the Raman spectra for HWCVD Si films on textured 1737 glass annealed in 4 RTP cycles at 800°C and 10.* (Pr4_08_2)

7.68 To assess the effect of joint overlap on total load capability, a series of models were run with joint overlap length ranging from 4.5 inches to 11.5 inches. A constant .020 bondline thickness was used for all runs. *The results of this analysis show that elastic joint strength increases with joint length, ranging from 13,341 lb./inch-width to a maximum of 16,313 lb./inch-width.* (Pr1_01_1)

7.69 We used rectangular, rhombus, circular, and elliptical cross sections of both isotropic and composite materials to verify the code for the ultimate-strength-based design. Code output was compared to exact closed-form calculations for these simple shapes. *For the rectangular and rhombus sections, both methods produced virtually identical results. For the circular and elliptical sections, the results were very close. The slight discrepancies, due to the piecewise straight-line discretization of circular and elliptical peripheries, became negligibly small as we refined the discretization.* We also used an actual 6-meter-long blade to validate the analysis option of the code. *The error between the computed and the actual properties was less than 2%.* (Pr4_04_1)

The next two most frequently used moves, the Problems Encountered move and the Optimization and Troubleshooting move, frequently co-occur and together immediately follow the Results move. In the Problems Encountered move, professional

EDR writers typically report the results that did not conform to the expected project outcomes. Sometimes these non-conforming results are further interpreted and explained. The Optimization and Troubleshooting move then describes attempts made to either solve the problem or optimize the general outcome. Excerpt 7.70 illustrates the Results – Problems Encountered – Optimization and Troubleshooting moves sequence; superscript identifiers are inserted to show move boundaries. The Problems Encountered move is *italicized*; the Optimization and Troubleshooting move is **bolded**.

7.70 (Results) The engine compression check for CNG bus 804 measured over 18% difference between the maximum and minimum readings. A cylinder leak down test was performed and confirmed a leak on cylinder 4. (Problems Encountered) *A cylinder bore scope evaluation, discussed in the next section, identified a slight oil leak past the valve guide seal along with carbon deposits on the valve stem and seat. Typically oil leaks from around a valve guide will cause carbon deposits to form on the valve stem and then eventually form on the face and the seat of the valve. These deposits will result in compression loss and over time poor performance.* (Optimization and Troubleshooting) **The cylinder head was removed and upon further inspection a crack was discovered at the edge of the valve seat. There were no engine or vehicle inspections performed on the test vehicles prior to the project. Therefore, it is difficult to assess when the crack occurred. This event was considered an anomaly and the cylinder head was replaced. The compression test was repeated with the new head and the difference between the maximum and minimum cylinder readings was 1.5%.** (Pr4_05_1)

7.2.4.3. Move Sequence Analysis

Table 7.10 shows the most frequent move types of the Results unit by move slots. It appears that professional EDR writers start the Results unit most frequently with the description of testing procedures, which is then followed by the presentation of results. The unit overall heavily relies on the use of the Results move, which is alternated with the Testing Procedures move in a cyclical manner throughout the unit. The Testing Procedures move sometimes is preceded by the Testing Equipment move, in which practicing engineers provide details on particular apparatuses used for testing. If testing equipment is described, its description typically appears close to the Results unit's beginning. Another move that follows the description of results relatively often is the Problems Encountered move, in which results that do not conform to the expected project outcomes are reported and often further explained. The Problems Encountered move seems to occur throughout the Results unit. Typically, it immediately follows the Results move and precedes the Optimization and Troubleshooting move, in which the attempts to resolve the problem or optimize the attained outcome are described. In fact, out of 28 occurrences of the Optimization move, 21 (75%) immediately followed the Problems Encountered move.

Another move that is quite regularly used by professional EDR writers is the Background move, which was observed in almost 30% of the corpus Results units. The Background move tends to occur most frequently immediately before the Testing Procedures move (42.86% of Background moves in the Results units), and somewhat less frequently immediately before the Result move (33%). Interestingly, despite a clear emphasis on reporting results, some professional EDRs included the Procedures move in the Results unit. The Procedures move was found in Results units of six professional EDRs (17.65% of Results units in corpus), typically immediately preceding the Results move.

Table 7.10 Most frequent Results moves by move slots

Move	Move slot number																																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Assumptions		1															1			1																	
Background	1	3			1	1	2	1		***2***		***2***					***2***				1				1		**1**	1			**1**					**1**	
Current design	1												1				1									1											
DOM functional												1																									
Follow-up activities			2		1		1				1										1		**1**						**1**								
Optimization		2	3	4		1	1	1	2	***2***			2		***2***	1	1		1	1	1		**1**		1	1											
Potential problems																							**1**							**1**							
Problems encountered	1	***5***	5	1	3	1	***4***	2	3	***2***	2	1		***3***	1	1		1	1	**3**		**3**	**1**	1	1				**1**				**1**		**1**		
Procedures	1				2			1	1	1		**3**		1		***2***			1																		
Project summary													1																								
Recommendations						1	1			1						1											**1**										
Results	***7***	**14**	***6***	**11**	**9**	**10**	***4***	**7**	**5**	**3**	***5***	**3**	**5**	***3***	**5**	***2***	**4**	**3**	**4**		**4**	1	**1**	**2**	**2**	**2**	**1**	**2**				**1**		**1**			**1**
Section blurb	3	2		1	1				1									1																			
Testing equipment	1	2		1		1		1		1		1																									
Testing procedures	**19**	2	**12**	***6***	***7***	***6***	**6**	***5***	***4***	**3**	**6**	***2***	***4***	**4**	***2***	**3**		**3**		***2***		***2***		**2**		1	**1**										

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Based on the results of the analysis of the Results organizational unit, it appears that four moves can be called obligatory: Testing Procedures, Results, Problems Encountered, and Optimization and Troubleshooting. Other moves found in the Results unit were not frequent enough to be included in the unit model. The model of the Results unit illustrates these findings and sequence (read from left to right).

Table 7.11 Proposed Results unit model

Results unit model			
Testing Procedures	Results	Problems Encountered	Optimization and Troubleshooting

7.2.5 Methods and Results

The merged Methods and Results (M&R) organizational unit is the longest unit in professional EDRs, containing the most move slots and showing the most variety of moves used. This is not surprising considering that this unit fuses together two of the most important rhetorical units of the design report: Methods and Results. As such, the merged unit's focus is two-fold: Describe the design procedures and report on the design outcome(s). Interestingly, the number of professional EDRs in the corpus with the merged M&R unit (n=37) was only slightly lower than that of EDRs with the stand-alone Methods unit (n=40), indicating that this is also a rather common pattern of EDR organization.

7.2.5.1. Move Frequency Analysis

Table 7.12 lists the predominant moves of the EDR M&R unit in their order of frequency. Out of 80 EDRs in the corpus, 40 included a stand-alone Methods unit, and three did not include a Methods unit at all. Therefore, frequency counts in this subsection are based on the 37 EDRs that included the merged M&R unit. As the table shows, a variety of moves are used by professional EDR writers in the M&R unit. As expected, the most prevalent moves of the unit are the most frequent moves of the stand-alone Methods and Results units, including the Results, Procedures, Testing Procedures, Optimization and Troubleshooting, and Problems Encountered moves. Another rather frequent move is the Background move, found in slightly fewer than 50% of the M&R units. Additional prominent moves include DOM Physical and Follow-Up Activities moves, each occurring in 14 of 34 M&R units of the professional EDR corpus.

Table 7.12 Frequent moves of the EDR Methods and Results unit

Move	Number of EDRs with the move (n=37)	Percentage of EDRs with the move (%)
Results	35	94.59
Procedures	34	91.89
Testing procedures	26	70.27
Optimization and troubleshooting	21	56.76
Problems encountered	20	54.05
Background	18	48.65
Description of materials (DOM) physical	14	37.84
Follow-up activities	14	37.84
Current design	11	29.73
Description of materials (DOM) functional	10	27.03
Previous work	10	27.03
Section blurb	9	24.32

7.2.5.2. Frequent Moves of the Methods and Results Unit

The most prevalent moves of the M&R unit, such as the Results, Procedures, Testing Procedures, Optimization and Troubleshooting, and Problems Encountered moves, have already been described and exemplified in the discussion of frequent moves in stand-alone Methods and stand-alone Results units. The functions and realizations of these moves remain relatively unchanged in the merged M&R unit. Thus, instead of repeating the discussion about these moves, this subsection will focus on less prevalent, but still fairly common moves that have not been discussed in previous subsections, specifically, on the Follow-Up Activities and Section Blurb moves.

In the Follow-Up Activities move, professional EDR writers identify work that needs to be done in the future. Writers can focus on work planned for another design project or activities that were not yet accomplished in the course of the same project. When describing follow-up activities, practicing engineers typically use the future tense as well as such verbs showing intention as *plan*, *intend to*, and *expect*, as in examples 7.71–7.76 (**bolded**). Note also the use of phrases denoting future activities (<u>underlined</u>).

7.71 <u>The next step toward</u> ultimate integration of the photoinjector, linac and FALCON laser is the production of Thomson scattered x-rays using the photoinjector beam at 5 MeV. This experiment **will demonstrate** the synchronization the photoinjector and laser systems, as well as demonstrating that we can overcome issues of pointing and stability. A beamline and electron final-focus optics have been designed for this experiment and <u>are currently under construction</u>. (Pr1_00_3)

7.72 The U.S. Department of Energy (DOE) indicates that the Next Generation Nuclear Plant (NGNP) **will be built** at the INEEL site <u>by 2017</u>. (Pr1_04_2)

7.73 **We expect** to complete our current suite of tests involving the use of static gas in the prototype units <u>by Q3 of FY05</u> and **should be able to finalize** the endstation design <u>by the end of the FY</u>. The high-pressure gas handling system needed to run performance tests with the cross-flow venturi in place **will be designed** <u>in late FY05</u> and **should be ready for use** <u>sometime in FY06</u>. (Pr1_05_2)

7.74 A similar **approach is planned** for the firmware implementation. **We intend to** add features and functionality incrementally, and slowly move on chip many of the functions and operations that **we will be performing** at first on the local computer. (Pr1_05_3)

7.75 This is also <u>an ongoing effort</u> and the physical requirements **will be updated** as more actual drilling experience is obtained and as longer reach, deeper water capabilities are defined. (1_06_1)

7.76 Fabrication of the actual test fixture **will commence** <u>upon successful completion of the wood model tests</u>. (Pr3_04_3)

The Follow-Up Activities move seems to occur most frequently following the Results move. In fact, 46.43% of all occurrences of this move in the M&R unit happens immediately after the Results move. Examples 7.77–7.78 illustrate this sequence, with the Follow-Up Activities moves **bolded** and the future tense verbs <u>underlined</u>.

7.77 Laboratory testing is essentially complete. Task 5 included: 1. Screening and verification of mechanical properties of resins, fibers, and adhesives for design and fabrication of CDP. 2. Temperature and Environmental Resistance of all material to be used in the CDP. 3. Measurement of Erosion and Mechanical Abrasion characteristics of interior and exterior coatings for CDP. **4. Future work will be conducted in these areas to evaluate possible improvements for the CDP as currently designed.** (Pr1_06_1)

7.78 Fig.19 shows the ratio of SR of the HPT before and after integration with the DOE. One can see that this ratio is in the range of 3 - 6. Taking into account the ratio of the DOE and the HPT diameters (300 μm and 75 μm), one could expect the maximum SR increase of 16, provided the optical efficiency of the DOE is 100%. **We believe, that due to a better understanding of the DOE fabrication and getting more experience, we will achieve the DOE optical efficiency of about 80–85%. Thus, one can expect a 10-fold improvement of the SR for the HPTs and DOEs of the above sizes.** (Pr3_06_4)

Another relatively frequent move of the unit, the Section Blurb move, appears in many organizational units of professional EDRs (e.g., Methods, Results). The move typically guides report readers by signposting the ways in which subsequent discussions are organized. This function of the Section Blurb move resembles that of the Overview of the Report described in Section 7.2.2, but rather than signaling the organization of an entire report, the Section Blurb move indicates the order of discussion in a particular EDR unit. This move (as indicated in excerpts 7.79–7.84) typically contains a reference to a particular EDR unit or section within it (**bolded**). A short descriptive summary of the unit or section then follows.

7.79 **Below,** the accomplishments associated with each of the proposed objectives will be listed in the respective order (see above for the list of the proposed objectives): (Pr2_04_1)

7.80 System Architecture-The system architecture is the build up of materials in the flexible system. **This section** explains in detail how all these materials fit together and dimensions of certain components. (Pr2_04_4)

7.81 **The following sections** describe how the design goals were met for this test fixture. (Pr3_04_3)

7.82 Details describing implementation of each of the above steps **are presented in the following sections**. (Pr3_04_5)

7.83 The motor simulation approach described in the previous section was used to calculate flux linkages and back EMF, motor torque and power, and rotor force.

Details of these simulations **are presented in the following sections**. (Pr3_04_5)

7.84 **In this section**, a model for the flywheel system (module and controller) is developed and validated. Measured parameter values will be used directly in the new controller, and the results of the analysis will lead to selection of the modal approach for the controller (next section). (Pr3_05_3)

7.2.5.3. Move Sequence Analysis

Table 7.13 demonstrates that the merged M&R unit largely consists of the interplay between the Procedures and Results moves. The Procedures move tends to be presented concomitantly with the Results move, resulting in a cyclical pattern of Procedures – Results moves. These two moves are at the core of the M&R unit whereas other moves seem to add pertinent information to this sequence. Although the pattern Procedures – Results is cyclical, occurring throughout the unit, the Procedures move seems to be used more often in the first half of the unit. The Results move then dominates the M&R unit's second half. This finding is not surprising and reflects the order of these two moves in the stand-alone Methods and Results units. The other moves that are used very frequently in the merged M&R unit include the Testing Procedures, Problems Encountered, Optimization and Troubleshooting, and Background moves. The Testing Procedures move, which alternates most frequently with the Results move, commonly occurs in the second half of the unit. The Problems Encountered and Optimization and Troubleshooting moves typically co-occur and are used most often immediately after the Results move throughout the M&R unit. The Background move appears to be used most frequently immediately before the Procedures move. In fact, 25 (73.53%) out of 34 occurrences of this move in the M&R unit were observed in the sequence Background – Procedures move.

Table 7.13 Most frequent Methods and Results moves by move slots

Move	Move slot number																																																									
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59
Background	3	1	3	3	4		1	1	2	1				1		***2***			1		1	***2***				1	1			1				1	**1**	**1**	1																		**1**				
Current design	***6***	1	2	1					1				1											1																																			
DOM functional		1	1	2	1	1	2		1		2			1	1			***2***		1		***2***		1				1			1												**1**																
DOM physical	1	5	3	1	4	1	1	1	1	2	2		2			1	2		2		1	1			1				**1**													**1**									**1**								
Follow-up activities		1	4	1	1			3		1		1	1		2	1	1		***3***							***2***		***2***					1		**1**																								
Need for project	1	1							1																																																		
Optimization				2	2		5	3	3	5	1	2	***3***	***4***		***2***		1		1	1	1	1			1		1	**1**																**1**		**1**					**1**					**1**		
Planning and project management	1						2							1																																													
Potential problems																																								**1**		**1**												**1**				**1**	
Previous work	4		2	3		3		1										1		1																																							
Problems encountered			2	3	2	3	4	3	2	1	2	2	1		1	***2***			1	1	1	1	1	1	1	1	**2**		**1**							**1**								**1**		**1**					**1**					**1**			
Procedures	**10**	**14**	**8**	**10**	**7**	**12**	***5***	**10**	***7***	***6***	***6***	***6***	***3***	**5**	***3***	**3**	***3***	***2***	1	**5**	1	**3**	**3**		***2***	**3**	**2**	1	**1**	*2*	**2**	**2**	**2**	1	**1**		**2**	1	**2**		**3**		**1**			**1**		**1**		**1**		**1**	**1**		**1**	**1**			**1**
Project summary	1		1																																																								
Recommendations						1						1	1												1																																		
Requirements and constraints	2			1			1																		1																																		
Results	2	***8***	***6***	***7***	***6***	***11***	**9**	***7***	**10**	**9**	**9**	**8**	**8**	**5**	**6**	***2***	**4**	**5**	**4**		**6**		**3**	***2***	**4**	1	**2**	**3**	**1**	**3**	1	**2**	1	**2**				**2**	1	**1**		**1**	**1**	**1**	**1**				**1**	**1**				**1**				**1**	**1**
Section blurb	3	2		1	1		1	1		1				1	1								1																																				
Testing equipment	1	1	1												1												1		**1**											**1**																			
Testing procedures	2	2	4	1	***6***	3	1	1	3	2	4	***5***	2	3	2	***2***	***3***	***2***	1	***3***	1	***2***	***2***	**4**			1		**1**		1		1			**1**								**1**			**1**	**1**	**1**				**1**				**1**		
Summary																							1									1																											

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Based on the findings reported in this subsection, it appears that the merged M&R unit contains the following obligatory moves: Procedures, Results, Testing Procedures, Problems Encountered, Optimization and Troubleshooting, and Background. Each of these moves was found in roughly 50% of the M&R units in the corpus. Two other prominent, yet less frequent and, therefore, optional moves included in the M&R unit model are the Follow-Up Activities and DOM Physical moves, each occurring in slightly fewer than 40% of the M&R units. In the unit's move model below (read from left to right), these moves are presented in parentheses, indicating that they are optional.

Table 7.14 Proposed Methods and Results unit model

Methods and Results unit model					
Background	Procedures and/or Testing Procedures	(DOM Physical)	Results	Problems Encountered	Optimization and Troubleshooting or (Follow-Up Activities)

Note: parentheses indicate optional move(s)

7.2.6 Discussion

The EDR Discussion unit seems to be the place where professional engineers discuss implications and/or applications of the design, thereby moving the discussion of the project beyond the specifics of the procedures and results toward the project's broader goals. This purpose seems to be congruent with the results of other genre analyses of RA Discussion sections (Stoller & Robinson, 2013). However, unlike RA Discussion sections (Kanoksilapatham, 2003, 2005; Stoller & Robinson, 2013), Discussion units in EDRs do not seem to contain the move that reminds the reader of the results obtained in the project. The semi-obligatory nature of re-statements of a study's results has been previously reported by Peng (1987) in chemical engineering RAs. In the present study, only one Discussion unit (of the 20 units in the corpus) began with the discussion of the project's results, followed by the description of future work and its implications. The difference between the rhetorical organizations of the RA Discussion section and EDR Discussion unit may be attributed to the nature of design and research projects. It appears that results of design projects are both reported and explained in the preceding Results or merged M&R or R&D (see Section 7.2.7) units. The Discussion unit then is left for connecting the results of the design project to the project's broader goals by focusing mainly the implications and impacts of the designed artifact as well as on its various applications.

7.2.6.1. Move Frequency Analysis

Of the 80 EDRs in the corpus, 53 did not contain a Discussion unit, whereas seven contained it as part of the merged R&D unit. Thus, the frequency counts in this subsection are based on 20 EDRs that contained a stand-alone Discussion unit. Table 7.15 shows the frequent moves identified in the EDR Discussion unit. As can be seen, the move that professional EDR writers use here the most is the Implications move, used in 50% of the Discussion units in the corpus. The Follow-Up Activities and Evaluation moves are two other moves that were used in 30% or more of reports each. Other relatively frequent moves of the unit include the Results and Background moves.

Table 7.15 Frequent moves of the EDR Discussion unit

Move	Number of EDRs with the move (n=20)	Percentage of EDRs with the move (%)
Implications	10	50.00
Follow-up activities	9	45.00
Evaluation	6	30.00
Results	5	25.00
Background	5	25.00

7.2.6.2. Frequent Moves of the Discussion Unit

The most frequent move of the stand-alone Discussion unit of the corpus is the Implications move, which provides EDR writers an opportunity to discuss the benefits and impacts of the designed artifact on society. Often, the Implications move involves discussions about (a) benefits from using the artifact (e.g. increased productivity) and decline in existing negative factors (e.g., lowered pollution rates) (7.85–7.86), (b) commercialization potential of the artifact (7.87), and (c) various ways of its implementation (7.88–7.90). Often this discussion includes the use of bulleted lists (7.85–7.86). Examples 7.85–7.90 demonstrate the use of this move; note the use of the modals (underlined).

7.85 Multiport dryer technology will provide the following **attractive benefits and impacts**:

- **Increased drying rate or increased productivity**, **a major impact** of the multiport cylinder dryer technology on the paper production industry, comes from **the potential to increase paper drying rates or production rates in existing machines**. An increase in drying rate can be viewed in two ways. The number of dryers can be reduced while paper production rate remains the same, or alternatively, system speed can be increased to produce paper at a higher rate with the same number of dryers. In the latter case, current experimental data show that **multiport cylinder dryers can potentially increase paper drying or production rates by as much as 20%** when compared with spoiler bar technology, **and by as much as 90%** when compared with existing technology without spoiler bars (see Fig. 14).
- … (Pr1_01_1)

7.86 **The benefits from this program include increased employment and reduced pollution**.

- The average residential rooftop PV power system installed in Sacramento, California will produce 2,890 kWh of electricity per year, and eliminate 3,583 pounds of CO2 and 1 pounds of NOX emissions in the first year.
- … (Pr1_02_2).

7.87 Since this development contract start date, the residential backup power market and the distributed energy markets have changed significantly. The way product is manufactured at Xantrex Technology has also changed. When the Model 5000 and 6000 are brought into production, there will more than likely be some changes dictated by current market conditions. Going forward, there already exists a credible scenario for **next generation products**. There is a mandate within the Xantrex organization to design all new products by using a small number of functional hardware and software modules. The next generation Model 5000, Power Unit, for example, would consist of three functional blocks, that are used in other products as well; two half-bridge modules, one DC to DC max power tracker and one remote display. **The advantages** of this design philosophy are **improved product reliability, lower product costs** and **easier application of mass production manufacturing techniques**. (Pr1_02_2)

7.88 **One possible implementation model is** a public-private partnership similar to that developed by WaterHealth International (www.waterhealth.com), which provides clean drinking water to more than a million people in rural India through publicly owned, privately managed village-scale water treatment centres. Through a three-way partnership between a local financial institution, a local NGO, and a company responsible for constructing and maintaining the water treatment centres (all working together with the local village governments), community-scale water treatment plants could be constructed in rural Bangladeshi villages. The water would not only be treated for arsenic, but also pathogens (using, for example, UV treatment) and other chemical contaminants, **enhancing the perception of treated water quality** (strategy 4). Users would pay a small fee for the safe drinking water that they collect from the treatment centre, but due to the low-cost of ARUBA the fee would remain affordable to those living on less than US$2 a day (strategy 6) and would be enough to cover both the capital and operating costs of the treatment centre. **This implementation plan** meets the design strategies listed above. In addition to being **effective and low-cost**, community-scale treatment using ARUBA leads to **ease in water quality monitoring** (strategy 5), **local water management** (strategy 7), and **waste management** (strategy 8). Villagers would not be required to maintain their own water treatment system, meaning that the system would be **convenient to users**. However, water delivery (strategy 3) would be essential for the success of the water treatment system. In India, poor villagers are willing to pay an extra free to have drinking water (purchased from WaterHealth centres) delivered to their doors. Convenience outweighs the added cost of this service. Therefore, we believe that an added delivery cost could be affordable in Bangladesh. (Pr1_09_3)

7.89 Design and mission studies conducted at NASA LaRC based on the above tunnel data have led to **consideration of several new pneumatic powered-lift PCW-type configurations**. The capability of the Pneumatic Channel Wing to **significantly augment lift, drag, and stall angle** to the levels reported herein demonstrates that this technology has **the potential to enable simple/reliable/effective STOL and possibly VTOL operations** of personal and business-sized aircraft operating from remote or small sites as well as increasingly dense urban environments. Such capability now opens the way for alternate visions regarding civilian travel scenarios, as well as both civilian and military aerial missions. **One such vision** is represented by the Personal Air Vehicle Exploration (PAVE) activity at NASA Langley Research Center. **Another vision**, a military Super-STOL transport, is discussed in the mission study of Reference 9 and Figure 21 above. **A third vision** is associated with the newly-postulated NASA Extreme-STOL powered-lift aircraft, where the use of both blowing-enhanced and thrust-enhanced lift augmentation appears quite promising. (Pr3_04_1)

7.90 The knowledge gained from our studies **will broadly impact the AFOSR**. Recent events in this Nation highlight the need for the detection and quantification of biological and chemical reagents for each person in the civilian and military population. **Our work provides the underpinning to develop technologies that address this need** (e.g. "wristwatch" sensors). **We expect** to obtain microsensors possessing unprecedented performance capabilities. We see the transfer of the tools developed in this program to other AFOSR fields as **an important benefit of the proposed work**. Two examples come to the fore. The methods developed in this program will allow for the invention of new optical diagnostic tools for mapping chemical and physical processes in micro- and nano-domains especially in small channels and near surfaces. (Pr2_05_3)

The second most frequent move of the Discussion unit, the Follow-Up Activities move, has functions comparable to those of this move's functions in the M&R unit. That is, this move describes activities related to the design project that are planned for the future (references to the future are **bolded**). Note the use of the future tense (underlined) in examples 7.91–7.94.

7.91 **More work remains to be done** to find PVD materials that will bond well to Teflon and resist abrasion, twisting, and vibration of the stator. In spite of these problems, Teflon seems the insulating material of choice as it is flexible, tough, easily deposited, and has very good dielectric properties. (Pr1_00_2)

7.92 **Work is also underway** to provide the necessary altitude simulation capabilities for ramjet direct-connect and free-jet testing modes. Altitude simulation capabilities are pertinent to evaluate ramjet performance during conditions when combustion chamber pressures are low. (Pr2_02_4)

7.93 **In the future,** Spinstand and MFM characterization of FIB-defined transducers will be used to study the nanoscale sensors and optimize the composition and structure of the 3-D recording medium from the angle of the signal-to-noise ratio (SNR) at high densities. (Pr2_04_1)

7.94 Integration of the Microjet Arrays with the Flex ICs: The design and fabrication of the MJAs has been described in detail elsewhere [1,2]. The MJAs will be fabricated in silicon and in Low Temperature Cofired Ceramic LTCC). An aluminum heat sink will be integrated into the MJA assembly to enhance the heat conduction away from the ICs. Since the MJAs are fabricated out of silicon or L TCC, both of which are not good conductors of heat, the addition of the aluminum heat sink **is expected** to enhance the heat transfer. An image of a representative heat sink is shown in Figure 8. (Pr2_04_4)

Another common move of the Discussion unit, the Evaluation move, provides the authors' assessment of the design project, which typically involves the discussion of the effectiveness of the artifact and/or the comments about the overall success of the design project. As such, this move often entails comparisons of the project outcomes to its objectives, which may result in the use of evaluative vocabulary, such as *successful*, *outstanding*, *accomplish*, *valuable*. Examples below illustrate these trends with evaluative words underlined.

7.95 The Proof-of-Concept testing **validated the successful function and utility** of the DWD system. **All drilling objectives were met** and performance of the interconnected DWD hardware and software elements was, especially for a complex new system with no history of drilling in an actual hole, outstanding. (Pr1_03_1)

7.96 As a result of this program, over 80 new PV arrays, utilizing developments from this program, have been installed on rooftops in the greater Sacramento metropolitan area. The Power Unit and Energy Storage Unit (ESU) have been built and tested, and **have met the technical goals set forth**. **The feasibility of such a system has been demonstrated**. … The goal for the Power Unit, operating at the higher voltage from the Energy Storage Unit, was to achieve a conversion efficiency of greater than 94% at 100% of rated output power, with total harmonic distortion below 5%. The Power Unit prototype **has exceeded this goal by achieving measured performance of 96% efficiency** and total harmonic distortion under 2%, at power levels of 30% to 100% of rated output power. (Pr1_02_2)

7.2.6.3. Move Sequence Analysis

Table 7.16 shows that the Discussion unit largely consists of the two moves: Follow-Up Activities and Implications. The Follow-Up Activities move tends to open the Discussion unit and is typically followed by the Implications move. Another move that is sometimes used by professional EDR writers to start the Discussion unit is the Evaluation move, which, though relatively frequent, does not appear to be frequent enough to be included in the Discussion unit model. Further, the Background move, observed in 25% of all Discussion units, does not seem to follow any particular pattern of use. This move has been found in a variety of move slots and can be followed by a number of moves; therefore, regularity in its use could not be determined.

Table 7.16 Most frequent Discussion moves by move slots

Move	Move slot number							
	1	2	3	4	5	6	7	8
Background	1	***2***	1	**3**	1	1		
Current design				1	1			
Evaluation	***4***	1	1				**1**	
Follow-up activities	**6**	1	**2**		1			
Implications	3	**4**	**2**			**2**		
Lessons learned		1				1		
Need for project	2							
Optimization and troubleshooting		1	1		**2**			
Potential problems			1	1				
Problems encountered	1	1	1		1			
Recommendations	1		1	1				
Results	1	***2***	1	1		1	**1**	**1**
Section blurb	1	1						
Testing procedures							**1**	

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Another frequent move of the Discussion unit, the Results move, seems to be used in conjunction with the Problems Encountered move and Optimization and Troubleshooting move to either (a) report on the results of the project that lead to optimization or troubleshooting efforts or (b) show the results of these efforts. Thus, the Results move most frequently either (a) precedes or follows the Problems Encountered move or (b) follows the Optimization and Troubleshooting move. However, none of these three moves is frequent in the Discussion unit. Thus, the communicative purposes of the EDR Discussion unit seem to be the discussion of implications and/or applications of the design, assessment of the overall success of the project, evaluation of the designed artifact, and sometimes consideration of possible improvements of the designed artifact.

Based on the results of the analysis presented in this subsection, the model for the Discussion unit seems to include two moves, Follow-Up Activities and Implications. The first move slot is typically occupied by the optional Follow-Up Activities move (presented in parentheses) whereas the second move slot is most likely occupied by the obligatory Implications move.

Table 7.17 Proposed Discussion unit model

Discussion unit model	
(Follow-Up Activities)	Implications

Note: parentheses indicate optional move(s)

7.2.7 Results and Discussion

Despite the reported growing frequency of merged Results and Discussion (R&D) sections in other registers, such as in chemistry RAs (Stoller & Robinson, 2013), the merged EDR R&D unit is rather infrequent. In fact, only ten EDRs in the corpus included this unit. Instead, professional EDR writers seem to report results either in the merged Methods and Results unit (n=37) or in the stand-alone Results unit (n=34). Further, the R&D unit found in the corpus seems to be much more results-oriented than discussion-driven, with a strong focus on the discussion of both encountered and potential problems as well as optimization and troubleshooting efforts. The subsections below describe the move frequency analysis, illustrate prominent moves of the R&D unit with examples, and provide move sequence analysis.

7.2.7.1. Move Frequency Analysis

Table 7.18 lists the predominant moves of the merged R&D unit. The most frequent move of this unit is the Results move, which was observed in all R&D units in the corpus. Other moves found in at least 50% of all R&D units include the Problems

Encountered, Testing Procedures, Optimization and Troubleshooting, and Follow-Up Activities moves. This is not surprising considering that the same moves were found to be prevalent in the stand-alone EDR Results and EDR Discussion units of the corpus. An additional move that was observed relatively frequently is the Background move. The results of these frequency counts, however, need to be considered with caution because the corpus contained only ten EDRs with the merged R&D unit, and therefore, in addition to the very low number of observations, this unit may not be characteristic of the professional EDR in the first place.

Table 7.18 Frequent moves of the EDR Results and Discussion unit

Move	Number of EDRs with the move (n=10)	Percentage of EDRs with the move (%)
Results	10	100.00
Problems encountered	9	90.00
Testing procedures	8	80.00
Optimization and troubleshooting	6	60.00
Follow-up activities	5	50.00
Background	3	30.00

7.2.7.2. Frequent Moves of the Results and Discussion Unit

The most prevalent move of the merged R&D unit, the Results move, has already been discussed (in Section 7.2.4.2) because this move was found to be frequently used in other EDR units, such as the merged M&R and stand-alone Results move. In the R&D unit, the Results move seems to fulfill the same role and is used both to objectively report outcomes of the design procedures and to interpret them. Examples 7.97–7.101 illustrate how this move is realized in the R&D unit, with pointers to visuals **bolded** and interpretations of results <u>underlined</u>.

7.97 **Results for these tests are shown in Figures 10 and 11**. The frequency response of the device is included only up to 50 Hz in order to capture the first resonance only. This resonance, at 28 Hz, is the translation of the shuttle in the direction of excitation. This is the motion that we are modeling and intending to dampen via magnetic forces. As magnets are added the damping ratio increases significantly and with the addition of the backing plate the damping ratio increases beyond a value of ~ = 1.0 (critical damping). (Pr1_05_1)

7.98 **Figure 13 shows** a measurement of an optic milled with a spherical tool with two curve profiles taken through the center of the optic. **Figure 14 shows** the profiles again, this time with the curvature of the optic removed, leaving the residual error from a perfect sphere. **This data shows** the maximum error at the center of the optic to be 900nm (0.9λ) which is significant. This can be compared to the spherical form that was removed from the diamond tool which had a departure of 1µm. This indicates that the error of this spherical tool is on the order of magnitude of the entire desired aspherical departure. (Pr1_07_1)

7.99 The test results for this surface **are also provided in Table 1**. **This table summarizes** eight tests conducted at accumulator pressures of 40, 80, 150, and 225 PSI. The performance of this impact surface was very consistent and produced a predictable relationship between impact velocity and HIC, **as shown in Figure 6**. Also, the low HIC results provided by these foam pads were somewhat surprising since other resilient foams previously tested had performed poorly. (3) The pad's freedom to slide vertically during the impact appears to contribute significantly to reducing HIC values. (Pr2_04_3)

7.100 The PCE modifications **resulted in** an input power reduction of 77 watts and an inverter efficiency of 95% at the maximum compressor operating speed of 7300 rps. The improved signal conditioning allows for better command and control of the NCe. The EMI filter changes **resulted in** an electronics box electrically "quieter" than any previously installed into the HST. (Pr3_02_2)

7.101 Examples of steady control of the VP using the PLC algorithms--PID (with a 5-s TPO period), PID (with an 8-s TPO period) and Fuzzy-along with the commercial control algorithm, **are shown in Figures 3-6**. The PID control (5-s TPO) provided the least VP variations around the setpoint. (Pr3_03_3)

The Testing Procedures move, frequently found at the onset of the R&D unit, describes tests and analyses carried out in the course of the design project. In the R&D unit, this move functions in ways similar to those described in Section 7.2.4. The Problems Encountered move in the R&D unit behaves similarly to this move's function in the Results unit, reported in Section 0. Specifically, this move accounts for unexpected outcomes of the design or testing procedures. In the R&D unit, 12 out of 22 occurrences (54.54%) of the Problems Encountered move were observed after the Results move. As examples 7.102–7.107 illustrate, the Problems Encountered move uses vocabulary indicating unexpected, non-conforming results (**bolded**) and sometimes includes authors' interpretation of these outcomes (<u>underlined</u>).

7.102 **The largest unexpected challenge encountered was** friction in the elbow joint and between the muscle and the arm. (See Figure 11.) Ideally, the whole system would have no static friction, and its viscous friction would come only from viscoelastic behavior in the muscles. (Pr1_04_1)

7.103 Because of the difficulty in measuring the shape of the optic, the team also attempted to measure the shape of the tools more directly. In these tests, the tool was scribed across the surface to leave the form of the tool as shown in Figure 15. In these tests, an unmodified (spherical) tool was scribed across the surface followed by a FIB modified (aspherical) tool. These scribe marks were then measured by a stylus profilometer. **Unfortunately**, the results of this measurement **did not match any expected value** and **were far enough off to bring the measurements into question.** (Pr1_07_1)

7.104 A post-HOST spin test of the NCC turbo machines **resulted in a failure** to start the circulator. Investigation revealed contact between the shaft and bearings with **substantial damage** to the anodized titanium surfaces <u>most likely caused by moisture contamination present in the loop</u>. (Pr3_02_2)

7.105 Compared to the commercial controller, the PID for temperature control implemented with I/O Control (not described here) introduced periods of accelerated drying and wetting that the VP controls **could not overcome** (see Figure 2). (Pr3_03_3)

7.106 The Xilinx FPGA routed completely. Three timing **violations were flagged as failed.** Two of the three violations had to do with the asynchronous clock-crossing boundary within the SpaceWire core where the 200 MHz data-strobe clock and the back-end's 125 MHz clock interact. <u>Per the core's literature, the use of multiple clocks is allowed, since the core should handle the interfacing properly. Likely, the constraint should be marked as a false path, but at this time, this has not been investigated further</u>. The third issue was a clock skew issue on the 200 MHz rising/falling edges. (Pr3_09_2)

7.107 We finally note that the reported **natural frequency ω_n tends to increase with increasing levels of damping**. At this time <u>we do not have an explanation for this</u>. (Pr1_05_1)

Similar to its behavior and function in other EDR units, the Optimization and Troubleshooting move in the R&D unit allows professional EDR writers to show that unexpected outcomes were acknowledged and demonstrate how these challenges in design work were addressed. Interestingly, Optimization and Troubleshooting examples 7.108–7.110 demonstrate that EDR writers frequently word their troubleshooting attempts very explicitly, using phrases such as *correct a problem*, *remedy a problem*, *address a condition*, and *overcome a problem*. These explicit markers of the move are **bolded** in the examples below whereas troubleshooting attempts are underlined. Sometimes, the Optimization and Troubleshooting move is also used not only to show attempts to solve an existing problem but also to indicate an effort to improve an already properly functioning design that can be optimized. At times, EDR writers simply acknowledge that such optimization is possible but was not attempted in the course of the design project (7.110).

7.108 **To correct this problem** elastic was strategically sewn into the suit on the shoulder and back. *However this did not work*, but created a shifting in the suit. **To remedy this problem** a new approach was taken one inspired by medieval armor. (Pr1_04_1)

7.109 Some delay in finding an acceptable set of tuned parameters for both the PID and Fuzzy controls was due to an interaction between the tested VP controls and the PID algorithm defined within I/O Control to control the air temperature in the chamber. **This problem was overcome** by re-wiring the control relays to allow the TC2 to control the Barber-Coleman valve while the PLC controlled the HUM and DEH. (Pr3_03_3)

7.110 At this time, such encoding has not been optimized but could be optimized in the future. (Pr3_09_2)

7.2.7.3. Move Sequence Analysis

Table 7.20 shows the most frequent moves of the EDR R&D unit by move slots. Similar to the move sequence in the stand-alone EDR Results unit, the move sequence in the EDR R&D unit tends to begin with the Testing Procedures move and continue with the Results move. This sequence appears to run cyclically through the whole unit. Other prominent moves of the R&D unit, such as the Problems Encountered move and the Optimization and Troubleshooting move, seem to be used to extend the Testing Procedures – Results sequence when needed. Follow-Up Activities is another frequent move that sometimes is used to develop this recurring sequence of the two most prevalent moves of the R&D unit. The Follow-Up Activities move tends to occur most often immediately after the Results move, but has also been occasionally observed following the Problems Encountered move. It appears that professional EDR writers use the Follow-Up Activities move to either discuss future plans when no problems were reported or describe possible future optimization efforts when specific problems were encountered in the design project.

Based on the analysis reported in this subsection, the model for the merged R&D includes five essential moves: Testing Procedures, Results, Follow-Up Activities, Problems Encountered, and Optimization and Troubleshooting. The sequence of the latter three moves seems to be somewhat flexible in that the Follow-Up Activities move can either follow the Results move or the Problems Encountered move. In cases where the Follow-Up Activities move follows the Problems Encountered move, the Optimization and Troubleshooting move does not seem to occur. Table 7.19 illustrates these findings and sequence (read from left to right) of the R&D unit moves.

Table 7.19 Proposed Results and Discussion unit model

<table>
<tr><th colspan="4">Results and Discussion unit model</th></tr>
<tr><td rowspan="2">Testing procedures</td><td rowspan="2">Results</td><td>Problems Encountered
or</td><td>Optimization and Troubleshooting
or
Follow-Up Activities</td></tr>
<tr><td colspan="2">Follow-Up Activities</td></tr>
</table>

Table 7.20 Most frequent Results and Discussion moves by move slots

Move	Move slot number																												
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
Background								1	**2**				**1**																
Current design																												**1**	
DOM physical																					**1**								
Follow-up activities		***2***		1		***2***		**2**	1	1				**1**															
Lessons learned																	**1**												
Optimization and troubleshooting			**3**	1	***2***	1	1	1			1		**1**			**2**				**1**									
Potential problems	1		1																										
Previous work	1																												
Problems encountered		**4**	***2***	**3**	**3**	1	1	1		1		1	**1**	**1**	1				**1**					**1**					
Procedures					1		1					1				1	**1**												
Recommendations					1																								
Results	***3***	**4**	***2***	***2***	1	1	**4**		**2**		**3**		**1**	**1**	**2**		**1**	1	**1**		**1**	**1**	**1**		**1**		**1**		**1**
Testing procedures	**5**		1	***2***	1	**3**		1		**2**		**2**		**1**	1	1		**2**		**1**		**1**				**1**			

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

7.2.8 Conclusion

The Conclusion unit seems to be the ubiquitous rhetorical structure of the EDR because it was present in 65 out of 80 (81.25%) professional EDRs in the corpus. Interestingly, in research on RAs, Conclusion is commonly discussed as part of the Discussion section (Kanoksilapatham, 2005, 2007; Nwogu, 1997; Stoller & Robinson, 2013). In the EDR genre, on the other hand, Conclusion is typically a stand-alone unit that serves several important functions. Specifically, analysis findings show that professional EDR writers use the Conclusion unit to summarize their most important accomplishments in the course of the design project. These writers also sometimes evaluate the overall success of the project, by comparing its outcomes to design requirements and using evaluative vocabulary. Lastly, this unit sometimes is used to outline plans for the future of design endeavors. The subsections below explore the EDR Conclusion unit by first presenting the move frequency analysis, then describing this unit's common moves, and finally examining these move sequences.

7.2.8.1. Move Frequency Analysis

Table 7.21 shows the most frequent moves of the EDR Conclusion unit. Clearly, the predominant move of the unit is the Summary move, in which EDR writers review the most important achievements of the design project. The second most frequent move of the unit, the Evaluation move, was observed in only 27.69% of all EDR Conclusions, which makes this move much less typical of an EDR Conclusion and does not qualify it for the inclusion of the Conclusion unit's model. These two moves are explained further and illustrated with examples below.

Table 7.21 Frequent moves of the EDR Conclusion unit

Move	Number of EDRs with the move (n=65)	Percentage of EDRs with the move (%)
Summary	50	76.92
Evaluation	18	27.69

7.2.8.2. Frequent Moves of the Conclusion Unit

The Summary move appears to be one of the crucial moves in EDRs. This is the rhetorical structure in which professional EDR writers condense months of work on the design project into a paragraph or two. The Summary move frequently contains a brief recap of the project's most important accomplishments, frequently including the main features of the designed artifact. Because the Summary move often condenses information presented in other EDR units, it regularly features numbered and bulleted lists. Excerpts 7.111–7.113 illustrate this tendency; references to conclusions are **bolded**.

7.111 **Key technical conclusions include**:
• Spectral control performance is important for TPV cell performance in a TPV system and influences the optimum bandgap for a given radiator temperature.
• Low bandgap TPV cells are conceptually enabling for both higher TPV efficiency and higher power density when spectral control limitations are included.
• Front surface tandem filters have achieved the highest spectral control performance for TPV energy conversion.
• Higher performance for front surface, frequency selective surface (FSS) filters is limited due to finite conductivity of the metal used to create the surface. Therefore, FSS filters do not satisfy the strict requirements for high spectral efficiency and high above band gap transmission as compared to current tandem filter technology.
• Back surface reflectors have achieved useful levels of spectral performance but less than the spectral performance of tandem filters. Higher performance for back surface reflectors is limited by free carrier absorption in the TPV cell layers.
• The spectral performance of radiator materials for TPV spectral control lags the performance of front surface, tandem filters for energy conversion in an application requiring maximum power density. (Pr1_07_4)

7.112 Based on the research conducted in this study **the following conclusions can be presented:**
(1) Design of a new type of face gear drives that could be applied in aircraft have been developed. Such gear drives provide: (i) application of new types of planetary gear drives with coaxial axes of input and output shafts, (ii) face gear

drives with split torque, (iii) new design of a planetary face gear drive.
(2) New geometry of face gear drives based on application of parabolic rack-cutters.
(3) Generation of face-gears by a worm of a special shape.
(4) Efficiency comparison of the various gear train arrangements was performed and generally the efficiency was lower for higher gear reduction ratios. (Pr3_04_4)

7.113 This project demonstrated that with minor engine and vehicle modifications the 20/80 H/CNG blend can be used in revenue service fleets with similar operational performance as CNG. **Specific findings include:**
• Minor engine and vehicle hardware modifications were required for the 20/80 H/CNG operation; a new fuel mass flow rate sensor and additional vehicle fuel tanks.
• All four test vehicles surpassed 24,000 in-service miles-- CNG buses accumulated a total of 71,951 miles: 39,088 for bus 802 and 32,863 for bus 804, H/CNG buses accumulated a total of 53,681 miles: 28,723 for bus 801 and 24,958 for bus 803.
• The H/CNG fuel contained approximately 86% of the energy as the CNG, 776 versus 905 Btu/ft3 (see Appendix B: Fuel Properties).
• On average, the four test vehicles operated approximately 86% of the available time. There was no significant difference in the availability of the CNG and H/CNG buses.
• The 20/80 H/CNG blend reduced NOx emissions by over 50% relative to the CNG control buses. There was no discernable difference in PM emissions for the two fuels. Emissions of NMHC and CO were near detection limits.
• A fuel economy penalty was experienced in the operation of the H/CNG blend; in-use fuel economy for the H/CNG buses was reduced by about 12% relative to the CNG operation on a diesel gallon equivalent basis. (Pr4_05_1)

7.2.8.3. Move Sequence Analysis

The two frequent moves of the Conclusion unit are the Summary move and the Evaluation move. Both of these moves tend to open the Conclusion unit; therefore, if one is present, the other one is most likely absent. In fact, only four EDRs contained both these moves, with the Summary - Evaluation sequence found in three of such cases.

Table 7.22 Most frequent Conclusion moves by move slots

Move	Move slot number 1	2	3
Evaluation	***15***	***3***	
Follow-up activities	1	**10**	**1**
Problems encountered		1	
Project summary		1	
Recommendations		1	
Summary	**49**	1	

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Based on the analysis presented in this subsection, the model of the Conclusion unit (presented in Table 7.23) includes only one obligatory move – Summary; no additional moves qualified for the inclusion in the model.

Table 7.23 Proposed Conclusion unit model

Conclusion unit model
Summary

7.2.9 Recommendations

7.2.9.1. Move Frequency Analysis

The most infrequent EDR organizational unit, the Recommendations unit, was found in only five EDRs in the professional corpus. In all five cases, the purpose of this unit seems to be to make suggestions for specific future design improvements. The paragraphs below illustrate the only obligatory move of this unit, the Recommendations move. Other moves, used in only one EDR Recommendations unit in the corpus include the Problems Encountered and Section Blurb moves. Caution needs to be taken in interpreting findings reported in this subsection because these results are based on a very small number of observations. Further, because the Recommendations unit is so rare in the professional EDR corpus, it appears that a stand-alone Recommendations unit does not belong in the EDR genre model.

Table 7.24 Frequent moves of the EDR Recommendations unit

Move	Number of EDRs with the move (n=5)	Percentage of EDRs with the move (%)
Recommendations	5	100.00
Problems encountered	1	20.00
Section blurb	1	20.00

7.2.9.2. Frequent Moves of the Recommendations Unit

The only frequent move of the Recommendations unit is the Recommendations move. In this move, professional EDR writers provide suggestions for future improvements of the design, as in examples 7.114–7.116. Note the use of the modals (**bolded**) and references to future (<u>underlined</u>).

7.114 <u>In the future</u>, the eXisting model or larger 3-D models **should be modified** to include blown tail surfaces and additional improvements to the pneumatic thrust deflection system. The following **should be experimentally investigated**. (Pr3_04_1)

7.115 Thus a <u>design objective</u> of a 300ºC tool **should be to eliminate this "hinge" effect**. As noted above, this requires that the problem of space to contain the strain gauges be addressed, as well as the trade off between strain in the steel to which the strain gauges are mounted and resolution of the measurements. (Pr1_09_1)

7.116 During this time, some <u>ideas for enhancements to the package were generated</u>. While the flexible circuit was used for internal control and data connections, power connections were still done as point-to-point connections between card cage boards. Replacing the wire bundle with a power PC board, **would continue the same modularity** provided by the flexible circuit. All the power interconnect wiring is between the NASA designed boards in slots 4, 5, and 6 and the single bay ARINC connector in the baseplate. A three slot "power foreplane" **could be located** in front of the commercial Compact-PCI backplane to provide the required power connections. The NASA designed boards **would plug into** the power foreplane eliminating the point-to-point wiring between boards. The shape of the NASA designed boards **would have to be changed** to accommodate the power foreplane, but they are custom boards anyway and **can be changed** as needed. (Pr3_06_5)

7.2.9.3. Move Sequence Analysis

Table 7.25 shows the moves observed in the Recommendations unit. As can be seen, the only frequent move here is the Recommendations move described and illustrated above. Other moves that were found in only one Recommendations unit each are the Problems Encountered and Section Blurb move. As expected, if the Section Blurb move occurs, it occupies the first move slot in the unit. The Problems Encountered move, on the other hand, seems to occur later in the unit and is alternated with the Recommendations move so that design challenges are pinpointed first in the Problems Encountered move and then are addressed in the subsequent Recommendations move.

Table 7.25 Most frequent Recommendations moves by move slots

Move	Move slot number								
	1	2	3	4	5	6	7	8	9
Problems encountered		**1**		**1**		**1**		**1**	
Recommendations	**4**		**1**		**1**		**1**		**1**
Section blurb	1								

Note: A shaded cell with a bolded number represents the most frequent move and the number of reports with it for a particular move slot. An unshaded cell with bolded and italicized number indicates the second most frequent move for the same move slot; the second most frequent moves found in only one EDR were not bolded and italicized.

Based on the results of the analysis in this subsection, it seems that the Recommendations unit, if present, contains only one obligatory move – Recommendations (Table 7.26). However, this unit occurred in the professional EDR corpus too infrequently to be called an obligatory unit of the EDR genre.

Table 7.26 Proposed Recommendations unit model

Recommendations unit model
Recommendations

7.2.10 Summary of Findings of the Genre Analysis

The results of the genre analysis demonstrate that there is a great deal of variation in the rhetorical organization of EDRs, both in the EDR overall structure and in the structure of EDR organizational units. At a more general level of the overall structure, the two most frequent organizational patterns (A – IMRC and A – I[MR]C) account for only slightly more than a third of the professional EDR corpus. At a level of EDR organizational units, if only moves observed in at least 75% of the unit corpora were to be included in the EDR model, only moves presented in Table 7.27 would be included.

Table 7.27 Obligatory EDR moves by EDR organizational unit

Organizational unit	Percentage of EDRs with the unit (%)	Moves occurring in at least 75% of the unit	Percentage of EDR units with the move (%)
Introduction	96	Need for project	87
Methods	50	Procedures	88
Results	43	Results	97
		Testing procedures	79
Methods and Results	46	Results	95
		Procedures	92
Results and Discussion	13	Results	100
		Problems encountered	90
		Testing procedures	80
Conclusion	81	Summary	77
Recommendations	6	Recommendations	100

Importantly, Table 7.27 demonstrates not only that a few moves can be considered truly obligatory in each EDR organizational unit, but also that most organizational units were not observed consistently throughout professional EDRs, with only the Introduction and Conclusion units found in more than 80% of the EDR professional corpus. Because of this variable nature of the EDR overall structure, even obligatory moves (i.e., moves observed in at least 75% of unit corpora) associated with less pervasive organizational units are used by EDR professional writers less frequently, which leads to further variability in the rhetorical organization of EDRs. These findings suggest that the EDR may not be a well-defined or developed genre, and, therefore, teaching this genre to novices would require more explicit instruction on the part of engineering faculty.

Despite the variable structure of the EDR genre, instructors who work with engineering students learning to write EDRs need to have a starting point, such as a simplified EDR model, to provide support for novice EDR writers. The results of the move analyses presented in the current study provide such a model. In particular, the analyses of eight identified EDR organizational units revealed that professional EDRs consist of 12 common moves, each of which can be used in more than one organizational unit and which tend to cluster in specific ways to form particular EDR organizational units. Certain moves were found to be more frequent and, therefore, more conventional than others in particular units. Further, moves in each unit, tend to occur in particular sequence. For instance, the Introduction unit most frequently consists of the following sequence of moves: Background – Need for Project – Current Project.

Table 7.28 presents all identified EDR organizational units with their typical moves alongside the description of EDR major sections provided in engineering writing textbooks. The table demonstrates several differences between what engineering students are taught about writing EDRs and how professional EDRs are actually written. In particular, textbook descriptions of the Discussion unit include discussions of unusual aspects of design and accounts of encountered problems. However, the analysis of professional EDRs in the corpus demonstrated that the Discussion unit typically contains references to future project-related activities and the description of the project's benefits, impacts, and applications. In addition the model presented in textbooks does not reflect the overall structures of EDRs determined by this study of professional EDRs, relying instead on a traditional, though not confirmed by corpus data, IMRDCR format.

Although this genre analysis is based only on one type of professional EDR, specifically those written for governmentally sponsored design projects, the results presented in this section suggest that the EDR discourse structure presented to students in textbooks might not be accurate and that other empirically driven EDR structures need to be used for teaching features of professional engineering written discourse to students.

Table 7.28 General structure and content of the body of EDRs according to engineering writing textbooks and based on the genre analysis

Major EDR sections and their content (according to textbooks)	Major organizational units and their frequent moves (based on genre analysis)
Introduction • Problem statement • Background information • Purpose of the project • Possible solutions/Plan for attacking the problem • Scope of the project • Overview of the report structure	**Introduction** 1. Background 2. Need for project 3. (Previous work) 4. Current design
Methodology • Requirements and specifications of the design solutions • Constraints • Alternatives available • Research completed, theories used, assumptions made, procedures and processes used to develop the design • Work breakdown: What was done when, why, and how • Team dynamics	**Methods** 1. (Background) 2. Procedures 3. (Description of Materials: Physical) 4. (Description of Materials: Functional) **Methods and Results** 1. (Background) 2. Procedures/Testing Procedures 3. (Description of Materials: Physical) 4. Results 5. Problems Encountered 6. Optimization and Troubleshooting / (Follow-Up Activities)
Results • Test and analyses results • Troubleshooting and remediation efforts • Optimization efforts	**Results** 1. Testing Procedures 2. Results 3. Problems Encountered 4. Optimization and Troubleshooting **(Results and Discussion)** 1. Testing Procedures 2. Results 3. Problems Encountered/ Follow-Up Activities 4. Optimization and Troubleshooting/ Follow-Up Activities
Discussion • Important specific features or unusual aspects of the design • Problems encountered	**Discussion** 1. (Follow-Up Activities) 2. Implications
Conclusions • Details about artifact that was designed • Evaluation of the success of the project in terms of meeting the original criteria and constraints	**Conclusions** 1. Summary
Recommendations	**(Recommendations)** 1. Recommendations

Note: Parentheses indicate optional organizational units and moves.

7.3. Analysis of Selected Lexico-Grammatical Features of Professional EDR Units

Chapter 6 examined the general grammatical characteristics of EDRs written in academic and professional settings. Building on the results of those linguistic analyses and the genre analysis of professional EDRs presented above, this section further investigates linguistic features of professional EDRs by examining core lexico-grammatical patterns across EDR organizational units. The analyses presented below follow the general procedures described in Section 5.2 and examine features presented in Table 5.1. Specifically, analyses in this section are based on core lexico-grammatical features, including major content classes, lexical classes of nouns and verbs, personal pronouns, passive voice, marking of tense and aspect, and modals.

In addition to the general procedures presented in Section 5.2, to prepare professional EDRs for subsequent linguistic analyses of EDR units, every professional EDR was divided into several text files, each containing an EDR organizational unit. Hence, ten sub-corpora were compiled containing texts representing the following EDR units, Abstract, Executive Summary, Introduction, Methods, Results, Methods and Results (M&R), Discussion, Results and Discussion (R&D), Recommendation, and Conclusion. Each file in these ten corpora contains text of a single EDR organizational unit. Because not all organizational units were present in all full-text professional EDRs, some unit-based corpora contained a rather small number of texts, which may bring to question their representativeness. Specifically, R&D and Executive Summary unit-based corpora consisted of only ten texts each whereas the Recommendations unit-based corpus contained only five texts (see Table 7.2).

7.3.1 Distribution of the Content Word Classes

Patterns similar to distributions of the content classes in full-text EDRs have been observed in the present analysis of EDR units (see Table J2 in Appendix J for results of significance tests). Figure 7.2 shows that nouns are by far the most frequently used part of speech in all EDR organizational units, occurring in most EDR units more than three times as frequently as any other content word class. Adjectives are used more frequently than adverbs in all EDR units. Verbs occur slightly more frequently than adjectives in most EDR units, except for the Introduction and Conclusion unit, which rely on adjectives to a greater extent than do other organizational units. Compared to all EDR units, the R&D unit shows the most frequent use of verbs and at the same time uses nouns the least of all units.

Text excerpt 7.117 illustrates an extremely frequent use of nouns in EDR Abstract units. The excerpt sentence contains 31 words, of which 19 are nouns (**bolded**), 1 is an adjective (italicized), and 1 is a main verb (<u>underlined</u>).

7.117 This **document** <u>summarizes</u> the **design** and **installation** of an *air-breathing* **engine test facility** at the **Alliant Techsystems, Inc. (ATK) Rocket Center, WV plant** located at **NAVSEA**'s **Allegany Ballistics Laboratory (ABL)**. (Abstract Pr2_02_4)

Text excerpt 7.118, from an EDR R&D unit, on the other hand, demonstrates a higher reliance on verbs and modals and, at the same time, a lower rate of occurrence of nouns and adjectives, compared to other EDR units. This sentence of 40 words consists of 8 nouns (**bolded**), 3 adjectives (*italicized*), 4 verbs and modals (<u>underlined</u>).

7.118 Because the **mill tool** <u>cuts</u> both on the *aspherical* **side** and also on the *back* **angle**, it <u>was thought</u> that the **forces** <u>generated</u> by these **edges** <u>might be forcing</u> the **tool** in or out radially during the *milling* **process**. (R&D Pr1_07_1)

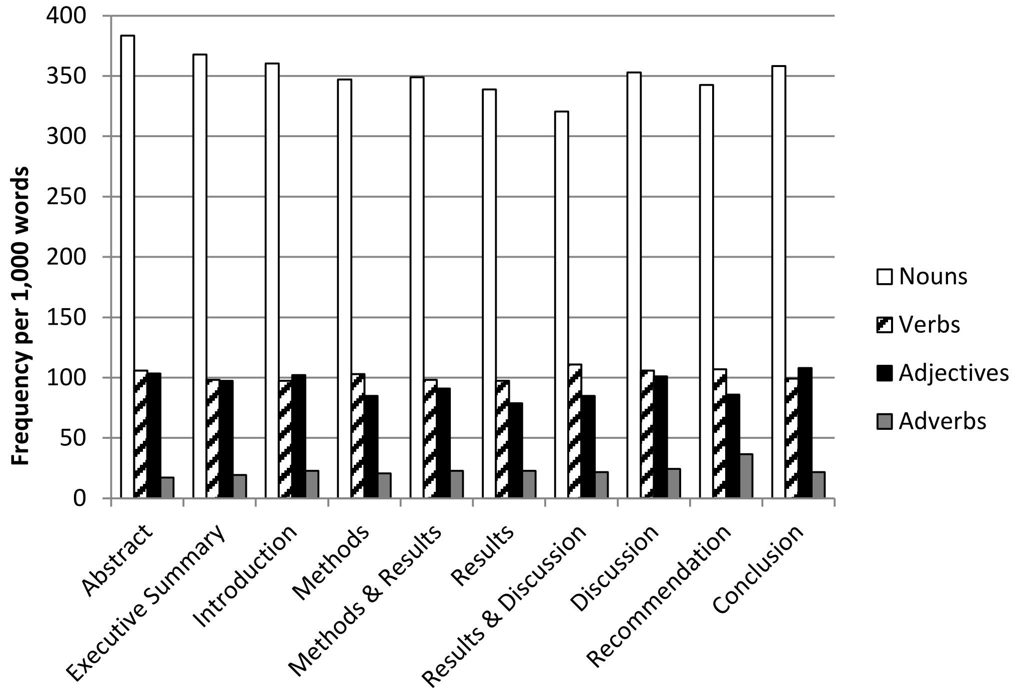


Figure 7.2 Distribution of nouns, verbs, adjectives and adverbs across EDR organizational units

The frequent use of adjectives is shown in two examples 7.119 and 7.20 from the EDR Conclusion unit. As these excerpts demonstrate, the frequent use of attributive adjectives (*italicized*) by professional EDR writers results in information-dense prose.

7.119 In this paper we presented *mathematical* and *numerical* models for *two-dimensional quasi-static eddy* currents in a *thin conducting* sheet. (Conclusion Pr1_05_1)

7.120 The *wide* variety of *unclassified* neutron *imaging* experiments that we have done at OUAL over the *past* few years using our *relatively simple* prototype *imaging* detector, combined with a number of *classified* Monte Carlo simulations of *potential* CSA *imaging* scenarios, have demonstrated the *potential* effectiveness of high-energy neutron imaging and validated its *proposed* use as a *nonintrusive* inspection tool in ESC applications. (Conclusion Pr1_05_2)

Although these general distributions of content word classes were expected based on the previous analyses reported in Chapter 6, it is interesting to uncover where the most discerning patterns of variation occur within professional EDR units. Specifically, the greater rates of occurrence of nouns in the Abstract and Executive Summary units are congruent with the results of previous research on disciplinary writing as these two organizational units are generally associated with the most information-dense style of writing. Conversely, the focus of the R&D unit on the description of testing procedures and results as well as the emphasis that EDR writers place on the discussion of encountered problems in this unit result in the higher density of verbs in this unit. Finally, the frequent use of adjectives, especially attributive adjectives, coupled with the high rates of occurrence of nouns in the Conclusion unit, appears to be another way to compress a lot of information in a few paragraphs.

These results suggest that linguistic variation exists across professional EDR units, and these differences (and similarities) in EDR writers' use of grammatical features are related to the communicative purposes of EDR units and their constituent moves. The sections below explore this variation further, beginning with nouns, and specifically with the analysis of variation in the use of semantic classes of nouns.

7.3.2 Nouns

As noted above, nouns are by far the most common content word class in professional EDRs. They are especially common in the information-packed Abstract and Executive Summary units. Figure 7.3 shows that there are further differences in the use of particular semantic classes of nouns across EDR organizational units. As can be seen, overall patterns of distribution of different semantic classes of nouns across professional EDR units look similar. In all EDR units, many of the common nouns refer to abstract concepts and processes (e.g., *cause, choice, criteria, quality*). The findings also show that other commonly used semantic classes of nouns across EDR units are concrete, quantity, and technical nouns. On the other hand, such classes of nouns as animate, cognition, and group nouns are used much less frequently across all EDR units. Similarities in the use of semantic classes of nouns across EDR units, including the reliance of all EDR units on abstract and process nouns, describing intangible, abstract concepts and processes, are not surprising. These distribution patterns of nouns across EDR units are similar to the distribution patterns of nouns found in full-text EDRs that have already been discussed in Chapter 6. This subsection, therefore, focuses on the differences related to the use of the semantic classes of nouns in different EDR units.

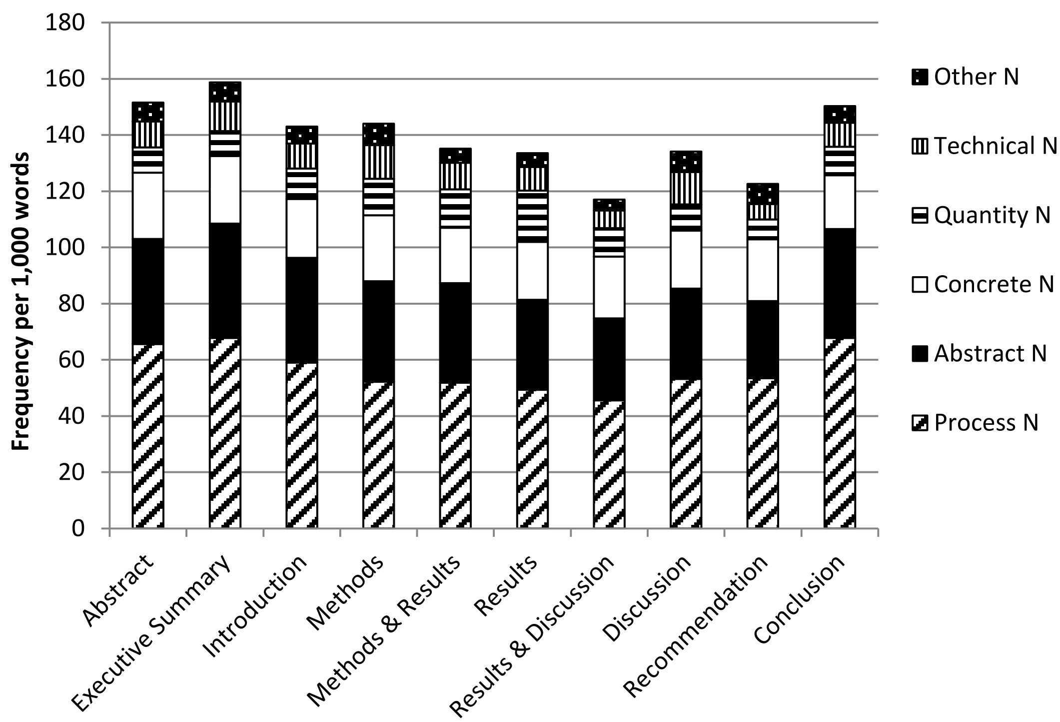


Figure 7.3 Distribution of nouns across EDR organizational units

Interestingly, the overall rates of occurrence of nouns reported in Section 7.3.1 parallel the observed rates of occurrence of the most prevalent semantic class of nouns, the process nouns. Specifically, the three EDR units that use process nouns most frequently are the information-dense units that summarize outcomes of entire design projects: Abstract, Executive Summary, and Conclusion. Conversely, the EDR unit that showed the lowest density of process nouns, the R&D unit, was already found to have the overall lowest rate of occurrence of nouns. In fact, compared to most EDR units, the R&D unit showed lower rates of occurrence for many semantic classes of nouns, including abstract and technical nouns as well as animate, cognition, and group nouns, grouped under the "other nouns" label. The lower rates of occurrence of nouns in this unit are surprising, but are likely connected to the focus of the R&D unit on discussing (a) problems that were encountered, (b) troubleshooting and optimization efforts, and (c) follow-up activities, all of which would generally call for the use of verbs. Excerpts 7.121 and 7.122 show a fairly common use of nouns (**bolded**) in the R&D unit but also demonstrate the frequent use of verbs and modals (underlined) in this unit.

7.121 During the next **report period**, alternative joint **configurations** will be investigated. **Designs**, which have been used by the **CDP design team** to successfully provide considerably higher tensile **capability**, will be evaluated for the **CDP**. (R&D Pr1_00_1)

7.122 **Fig**. 2 shows a **series** of **SEM images** of **resist** summarizing **results** from these **tests**. **Hexagons** with **widths** of 880 and 900 **nm** could not produce **rings** which could be resolved. The 870 **nm** wide **hexagons** and 870 **nm diameter circles** both successfully produced resolved **rings**, but the **circles** produced **rings** of much higher **quality**. The 900 **nm circles** nearly produced resolved **rings**. The **rings** would just start to have **breaks** in them at a **dose** (**time** of uv **light exposure**) sufficient to produce the **gap** between the **rings**. (R&D Pr1_01_2)

Another interesting result of the analysis of semantic classes of nouns across EDR units is related to the considerably higher rates of occurrence of quantity nouns (e.g., *percent*, *frequency*, *temperature*, *volt*) in the Results unit, especially when compared to such EDR units as Recommendations, Abstract, and Executive Summary. In fact, professional EDR writers use more than twice as many quantity nouns in the Results unit as they do in any of these three units. This finding is not unexpected, however, considering that practicing engineers' discourse in the Results unit is centered on reporting results of design procedures, which typically revolve around discussions of quantities, duration, and amounts. Other EDR units with a relatively high density of quantity nouns, specifically Methods and M&R units, also contain moves that report on design procedures and results, thereby, bringing about the need to use this semantic class of nouns. The Recommendations, Abstract, and Executive Summary units, on the other hand, do not appear to be focused on the procedures or results of the design to the same extent. Excerpts 7.123–7.125 show the use of quantity nouns in the Results unit (**bolded**).

7.123 The prototype was tested over a **temperature range** of -20F to 160F. The prototype aimer worked well over this entire range. The lasers illuminate immediately when the **temperature range** is between 40F and 160F. When the aimer is cold, a warm-up **period** is required for the heaters to bring the laser modules up to the operating **temperature**. At -20F, this warm-up **period** approximately 1 **minute**. (Results Pr1_07_3)

7.124 The EKF performed almost flawlessly (Figure 11, right), with a .35 **percent** relative error over a distance of 593 **meters**, whereas the SLAM algorithm became utterly useless after 100 **meters** and ended up with an error of about 45 **meters**. GPS was intermittently useful depending on how cluttered the environment was and how close the robot came to each building. (Results Pr2_06_1)

7.125 It can be clearly seen that the relaxation oscillator circuit performed very well throughout the **temperature range** between 210 and –190 °C as the **frequency** of the output signal fluctuated with variation in the sensed **temperature**. While the **frequency** of the output signal had a value of about kHz at room **temperature**, it decreased to about 2.072 kHz at 210 °C and attained a **frequency** of 15.048 kHz when the **temperature** approached –190 °C. This **frequency** response, which took on a hyperbolic trend with **temperature**, is depicted in figure 6. Plotting the **period** of the output signal versus temperature reveals, as expected, a linear response as shown in figure 7. No change was experienced by either the duty cycle or the rise **time** of the output signal throughout the test **temperature range** as shown in figures 8 and 9, respectively. (Results Pr3_08_1)

These findings indicate that despite generally similar patterns of distribution of semantic classes of nouns, professional EDR writers rely on specific semantic classes of nouns, such as process or quantity nouns, differently across EDR units. To investigate these results further, the next subsection explores the distribution of pronouns, that is, function words that are generally associated with more conversation-like registers and whose distribution patterns are connected to the distribution of both nouns and verbs.

7.3.3 Pronouns

Figure 7.4 displays frequencies of personal pronouns across EDR units. In all units, first person pronouns are the most frequent type of personal pronouns, followed by third person pronouns; second person pronouns are virtually non-existent. Because only multi-authored EDRs were collected for this study, all first person pronouns in the corpus were the plural form *we*. Despite these overall similarities, Figure 7.4 also shows that EDR writers use pronouns across EDR units rather differently, depending on each unit's rhetorical objectives.

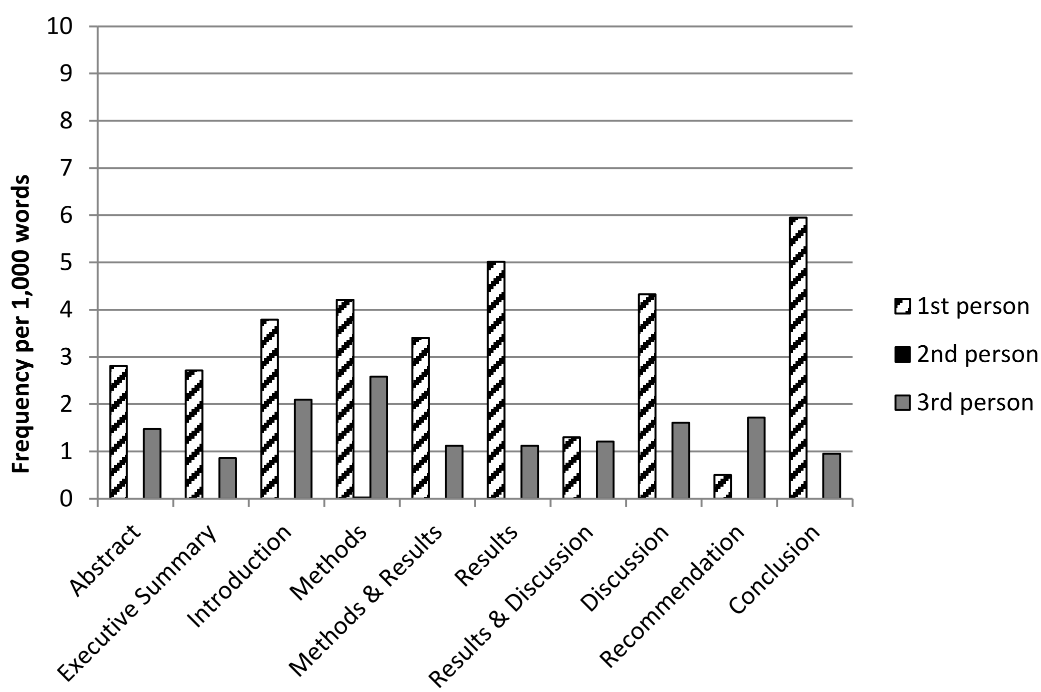


Figure 7.4 Distribution of pronouns across EDR organizational units

Overall, pronouns are used most frequently in the Methods and Conclusion EDR units. In part, this finding can be attributed to the fact that these two units show the highest rates of occurrence of first and third person pronouns, with the Conclusion unit showing the most frequent use of *we* and the Methods unit exhibiting the highest density of third person pronouns. Further, the Methods unit is the only unit in which EDR writers use second person pronouns. Another EDR unit where both pronouns overall and first person pronouns are used very frequently is the Results unit. The R&D and Recommendations units, on the other hand, show the lowest rates of occurrence of both pronouns overall and first person pronouns.

In addition to the quantitative differences in the rates of occurrence of pronouns, the results of the analysis indicate qualitative differences in the use of pronouns across EDR units. That is, the same type of pronouns can fulfill different functions, depending on the communicative purposes of the unit in which pronouns are being used. For instance, both the Conclusion and Results units show high density of first person pronouns. In the Conclusion unit, professional EDR writers use *we* most often to summarize outcomes of the project, report on the project's progress (**bolded**), and outline their future plans (<u>underlined</u>), as seen in excerpts 7.126–7.128.

7.126 The method assumes a specific layout of composite materials within the blade. In principle, it is possible to handle a general layout for the structure, but the code usage would become cumbersome. Therefore, <u>we plan to</u> extend our code to accommodate only a few more layouts popular with designers. Results show that root reinforcement contributes significantly to blade weight and stiffness. However, **we have used** only a simple trend-based relation to design this important component. <u>We intend to</u> seek guidance in refining the root design, including bolt attachments, and we also plan to extend the code to accommodate edgewise loading. (Conclusion Pr4_01_4)

7.127 **We have found** that deposited emitters on mc-Si give low performance likely due to the lack of phosphorus gettering and hydrogen passivation. To solve this problem, <u>we will focus</u> on hydrogenation techniques that do not rely on SiN on the front surface. (Conclusion Pr4_08_2)

7.128 The wide variety of unclassified neutron imaging experiments that **we have done** at OUAL over the past few years using our relatively simple prototype imaging detector, combined with a number of classified Monte Carlo simulations of potential CSA imaging scenarios, have demonstrated the potential effectiveness of high-energy neutron imaging and validated its proposed use as a nonintrusive inspection tool in ESC applications. The design of the RFQ/DTL accelerator system associated with the neutron source is complete and **we are making good progress** on the development of other key components including the high-pressure "windowless" gas target endstation and a full-scale prototype of the imaging detector. <u>We are poised to commit</u> to the construction of a full-scale neutron imaging system facility at LLNL when sufficient funds become available (note that procurement of the accelerator system will essentially drive the deployment schedule). (Conclusion Pr1_05_2)

In the Results unit, first person pronouns are also very common (**bolded** in excerpt 7.129), but here they are commonly used to explain testing procedures and report on their results (<u>underlined</u>).

7.129 **We** then <u>picked up</u> another joint of pipe and <u>drilled</u> ahead at about the same conditions as immediately before, but observed stick-slip while still in the shale. **We** <u>adjusted</u> rotary speed and WOB until **we** <u>reached</u> a high ROP, although this was accompanied by high torque. When **we** <u>entered</u> the Misener, torque increased even more (periodically over 7000 ft-lbs) but ROP remained high to 1627' (22' in 23 minutes = 57.4 fph), where **we** <u>lost</u> the DWD signal. After repairing the wireline connection **we** <u>attempted</u> to resume drilling but were called away from the rig floor because of a lightning storm in the area. After approximately 20 minutes **we** once again <u>tried to resume drilling</u>, but both the electronic and hydraulic gauges showed a significant drop in standpipe pressure (at the same flow rate) compared to conditions before leaving the floor. **We** <u>did not want to risk drilling</u> with what might be a washout and there was not enough time left in the day to resolve the problem. **We** <u>had exhausted</u> our allotted test time, and GTI had more work scheduled immediately after ours, so the Phase 2 test ended at this point. (Results Pr1_03_1)

Another EDR unit that also describes testing procedures and their results but showed surprisingly low rates of occurrence of personal pronouns in all three categories is R&D. While the a very low density of personal pronouns, and especially first person pronouns, in this unit is remarkable, it could be ascribed to the focus of this unit on reporting both results and problems encountered during the design process. It is possible then that EDR writers would want to avoid using first person pronouns, distancing themselves in this way from the challenges they encountered.

Overall, the patterns of pronoun distribution across EDR units seem to have a close connection to the distribution of the content word classes, which was expected. For instance, the heavy reliance on nouns in information-packed Abstract and Executive Summary units is offset by less frequent use of pronouns. However, this connection between distribution of nouns and pronouns was not observed in all EDR units. For example, the higher frequency of nouns in the Conclusion unit does not seem to correspond to a lower density of pronouns in this EDR unit.

7.3.4 Verbs

Figure 7.5 displays the rates of occurrence of six semantic classes of verbs previously explored in Chapter 6. The analysis of full-text EDRs in Chapter 6 revealed that professional EDR writers heavily rely of on activity and mental verbs. Figure 7.5 shows that these two semantic classes of verbs are used most frequently across all professional EDR units and that their patterns of distribution do not differ significantly. The only verb class that showed statistically significant differences in its use across EDR units was the occurrence verbs.

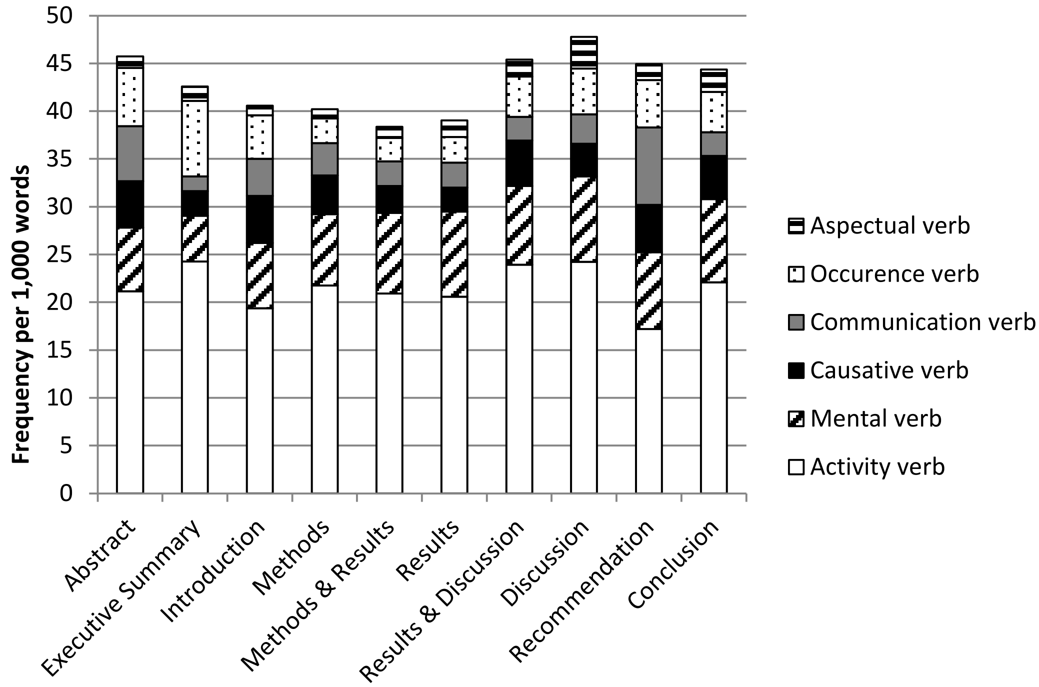


Figure 7.5 Distribution of verbs across EDR organizational units

Occurrence verbs, reporting events that happen apart from any volitional activity (e.g., *become, change, grow, increase*), were found to be a discerning characteristic of full-text professional EDRs in Chapter 6. This class of verbs also shows rather different patterns of use across professional EDR units, with occurrence verbs being most frequent in the Executive Summary and Abstract units and least frequent in the stand-alone Methods and merged Methods and Results units. One commonly used occurrence verb in professional EDRs is the verb *increase*, which is most frequently used to explain the uses and/or benefits of using the designed artifact. As examples below demonstrate, it is common for the verb *increase* to describe the designed artifact (**bolded** in 7.130–7.132). Professional EDR writers also use the verb *increase* to report results of analyses and procedures (**bolded** in 7.133) and to highlight the benefits brought about by the designed artifact (**bolded** in 7.134).

7.130 The primary objective of this program is to develop a readily manufacturable product that **will increase** US domestic PV power system production and installed capacity, by reducing the total installed cost and **increasing** the reliability of residential rooftop mounted PV power systems. (Abstract Pr1_02_2)

7.131 Accordingly, this proposal seeks to develop strategies **to increase** CBsensor response by replacing the linear, single photon response of present sensors with extremely nonlinear optical responses. (Abstract Pr2_05_3)

7.132 This project is motivated towards developing and testing inverters that will allow distributed energy systems to provide ancillary services such as voltage and VAR regulation, and **increase** grid reliability by seamlessly transitioning between grid-tied and stand-alone operation modes. (Abstract Pr4_07_1)

7.133 Finally, we investigated two methods **to increase** Jsc from the top cell of an a-Si/c-Si tandem device. The substrate temperature **was increased** from 200 to 300°C to increase the bandgap of a-Si. This **did increase** the short circuit current however, the Voc of tandem devices dropped when the deposition temperature was increased. Therefore, **increasing** the deposition temperature above 200°C was been dropped from further consideration. In another attempt **to increase** the current from the top cell, we **increased** the i-layer thickness from 0.25 µm to 0.35µm **to increase** absorption in the i-layer. (Executive Summary Pr4_08_2)

7.134 Laboratory-scale tests and assessments suggest that a multiport cylinder dryer **can** potentially **increase** paper drying or production rates by as much as 20% when compared with spoiler bar technology, and by as much as 90% when compared with existing technology without spoiler bars. (Abstract Pr1_01_1)

The results of the analysis of verbs according to their semantic meanings indicate somewhat similar patterns of distribution of verb classes across EDR units, with active and mental verbs being used most often across all units. However, the results also point towards both quantitative and qualitative differences in the use of verb classes across EDR units. Not only are certain semantic classes of verbs used much more or less frequently in different EDR organizational units, but even when different organizational units rely on the same semantic class of verbs, individual verbs belonging to this semantic class can be used in distinct ways across these units. The next subsection further explores differences in the use of verbs across EDR units by examining one particular type of verb phrase, the passive voice.

7.3.5 The Verb Phrase: Passive Voice

Figure 7.6 displays the frequency of use of agentless passives and *by*-passives. Consistent with the results of the analysis of full-text EDRs reported in Chapter 6, agentless passives are much more common than by-passives across all EDR units. Interestingly, however, the results of the present study indicate differences between the rates of occurrence of agentless passive voice structures. Specifically, agentless passives are used much more frequently in the EDR units that report procedures (Methods unit), results (Results and R&D units), or both (M&R unit). This finding was expected considering that agentless passives are commonly used to de-emphasize the role of the action agent and are frequently formed with activity and mental verbs to describe design procedures and outcomes. As examples 7.135–7.136 show, in such agentless passives (**bolded**), the implied agents are typically EDR writers.

7.135 We have made substantial modifications to LSP in order to better integrate it with the other components of the project. In particular, the control parameters set and problem generator **has been described** in PYTHON. The ability to read and write PDB files **has** also **been added** to facilitate data exchange between codes. (Methods Pr2_07_1)

7.136 Most recently, the UV laser system **has been completed**, and a photoelectron beam **has been produced**. In the case where the RF drive power **is reduced** to the point where photoelectron current dominates over dark current, the solenoid lenses **can** again **be used** to image the beam from the photocathode. (M&R Pr1_03_2)

Agentless passives are also regularly used to describe the design components (in the Description of Materials Physical move) and their function(s) (in the Functional Description of Materials move). These descriptions, typically use agentless passives in the present tense (**bolded** in 7.137–7.138), with the agents of the verbs frequently assumed to be the EDR writers.

7.137 The sub is a tubular tool, 7" in diameter by approximately 85" long, with a central electronics/sensor package suspended by three-legged supports inside the structural housing (see Figure 1). The metal parts of the tool **are made** from non-magnetic materials to allow proper magnetometer operation, and the structural case **is sized** for the loads typical in drilling 8-1 /2" hole. Strain gauges for torque, bending, and weight on bit **are bonded** to the outer case and **covered** with metal "clam-shells" that protect the gauges from mud flow in the annulus but are vented to the annulus pressure. Other sensors **are mounted** in the central package. (Methods Pr1_03_1)

7.138 Fig 5 shows the electronics used to drive each channel. The triggering and timing distribution system **is provided** by the FPGA, while each pulse **is being** monitored and recorded by the data acquisition system, to allow for comparison, calibration and improved data analysis. (M&R Pr1_05_3)

Interestingly, while the descriptions of the design components generally utilize agentless passives in the present tense (<u>underlined</u> in 7.139), agentless passives describing procedures and results often rely on the past tense (**bolded** in 7.139). Agentless passives in the present tense are also commonly used to provide background information about design and testing procedures (*italicized* in 7.139). Note that when background is provided, the implied agents are no longer EDR writers.

7.139 *The wafers <u>are grown</u> with a crystal orientation of <111> of f 4.0 ± .5° towards the <110> plane. Once the silicon <u>is cut</u> into wafers, the backside <u>is</u> uniformly chemically <u>etched</u>. As mentioned, the two thinning methods studied are plasma etch and grinding-polishing.* In this study, the wire bond and flip chip wafers **were thinned** to an approximate thickness of 50 microns. The characteristics that **were studied** were surface roughness and surface morphology using a Dimension 3000 atomic force microscope (AFM), Knoop microhardness with a Beuhler microhardness indenter and a Hitachi S-2300 scanning electron microscope (SEM), and residual stress with a Phillips X'Pert System X-ray diffraction. In order to simplify the material handling during the material analysis, the wafers **were cut** into individual dies. (M&R Pr2_04_4)

Throughout EDR organizational units, and especially those units that focus on design procedures and/or results (i.e., Methods, Results, R&D, and M&R), it is common for agentless passives to be used to draw reader's attention to particular data or visuals. The implied agents in these cases are typically EDR writers, and verbs, such as *demonstrate*, *depict*, *describe*, *illustrate*, *plot*, *present*, and *show*, are typically used in the present tense (7.140–7.143). The present tense agentless passives are also frequently used to describe calculations. These passives commonly use mental and existence verbs, such as *assume*, *calculate*, *compute, define*, *derive*, *determine*, and *multiply* (7.144).

7.140 Creep and stress rupture data **are** graphically **presented** in Figures 16 through 19. In the longitudinal direction, high stress exponents **are observed** at the temperatures studied, consistent with the threshold behavior for this alloy. (M&R Pr1_04_2)

7.141 An image of the photoelectron beam **is shown** in Fig. 18. (M&R Pr1_03_2)

7.142 The leading edge section **is shown** as an exploded view in Fig. 4. The leading edge **is formed** primarily from oxygen-free high conductivity (OFHC) copper, selected because of a combination of its yield strength and its high thermal conductivity. The material properties of this material **are presented** in Table 3. (M&R Pr3_04_3)

7.143 The experimentally obtained values of conversion versus time for the different sizes **are plotted** in Figure 3. (Results Pr3_09_3)

7.144 It is also important to note that the ROP values **are not derived** from instantaneous measurements but **are calculated** by summing the total time spent on bottom and rotating for each stand (or joint) of drill pipe. (Results Pr1_03_1)

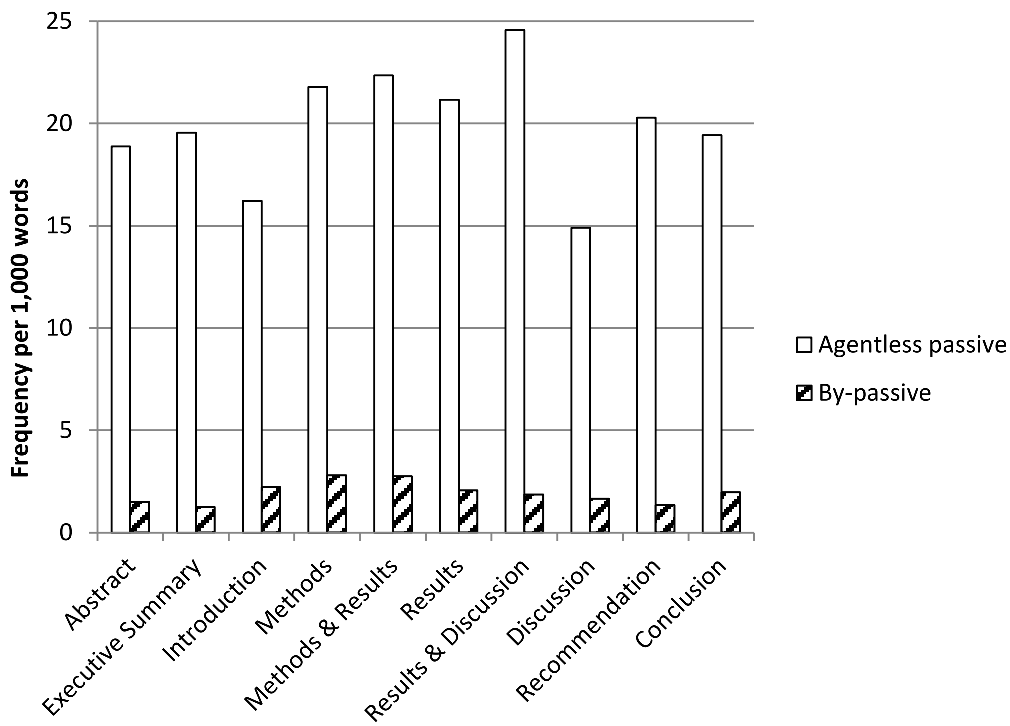


Figure 7.6 Distribution of passive voice across EDR organizational units

In contrast to agentless passives, common agents of *by*-passives (**bolded** in excerpts 7.145–7.149), especially in Methods and M&R units, are abstract processes and concepts (underlined), often expressed through nominalizations (*italicized*).

7.145 This is a non-inverting amplifier. The total gain of the amplifier **is determined** by the ratio of two external resisters Rr, R2, and the voltage divider. (M&R Pr3_03_1)

7.146 If the exchange-breaking layers are sufficiently thick, the surface effects are minimized and thus the magnetic anisotropy **is determined** by the interplay of intrinsic crystalline and shape anisotropy. (M&R Pr2_04_1)

7.147 The heat that is transferred to the steam **is controlled** by the liquid mass flux, which is controlled to a desired value by an AC adjustable-frequency drive, and the heat provided to the liquid in the heater. (Methods Pr1_01_1)

7.148 The cells **were harvested** by *centrifugation* (10 min at 10,000 X g), then resuspended in 1% raffinose to an OD550 = 0.8. (Methods_Pr2_08_1)

7.149 Developing the GIS **was accomplished** by a *combination* of interpretation of imagery and creation of new files by digitizing and rectifying paper printouts from the LOD and the Mosul Dam staff. (Methods Pr1_07_1)

Interestingly, the Discussion unit showed the lowest rates of occurrence of passive constructions, especially agentless passives. While surprising, this finding can be linked to the specific moves commonly observed in the Discussion unit. Specifically, the most frequent move of this unit, the Implications move, describes benefits from using the artifact, the decline in existing negative factors, the commercialization potential of the artifact, and the various ways in which the artifact can be implemented. It is likely that, when discussing these positive outcomes of the design project, professional EDR writers would not want to de-emphasize their role in the project, resulting in the use of active voice.

Figure 7.6 and the text excerpts presented above show that the use of passive voice varies across EDR units in terms of (a) overall frequency of use, with both forms being very frequent in the units reporting procedures and their outcomes (i.e., Methods, Results, M&R, and R&D), and (b) the different functions the passives are used for. The next subsection further explores variation in the verb phrase by examining tense and aspect marking of all verb phrases across EDR units.

7.3.6 The Verb Phrase: Tense and Aspect

Analysis of the variation in the marking of tense and aspect in professional EDRs provides one more perspective on the use of verbs in EDR units. Figure 7.7 displays distribution of tense and aspect marking across ten EDR units, showing that, consistent with previous research (Biber, 2006a), the present tense is used more frequently than past tense across all units.

The preference for the use of the present tense is especially pronounced in the Discussion, Recommendations, and Introduction units. In fact, in both the Discussion and Introduction units, present tense verbs are more than three times as frequent as past tense verbs. These findings are somewhat surprising, considering that it is rather common to find the frequent use of the past tense in Introductions of many academic written registers, where it is used to situate current work within the previous body of knowledge. The past tense is also commonly used in Discussion sections of RAs to remind the readers of the study's main outcomes (Kanoksilapatham, 2003, 2005; Stoller & Robinson, 2013). However, these general tendencies in the use of the past tense in RAs do not seem to apply to EDRs.

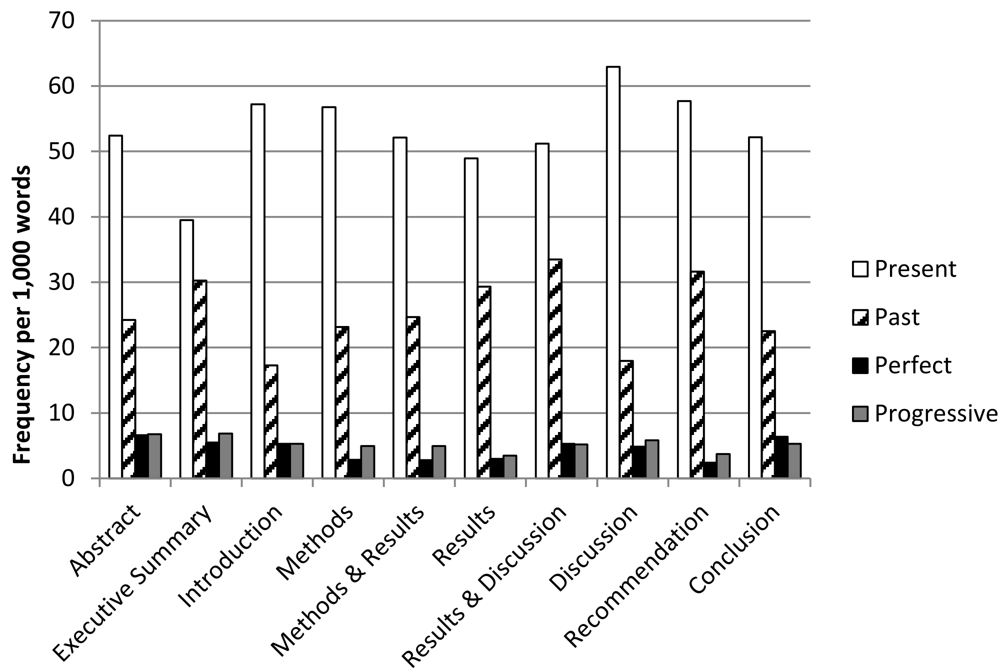


Figure 7.7 Distribution of tense and aspect across EDR organizational units

The much greater preference for the use of the present tense in the Introduction unit may be explained by the fact that EDR Introduction units typically review less literature than RA Introduction. In fact, McKenna (1997) made a similar observation in a discussion of engineering reports and attributed it to the fact that practicing engineers' reliability is verified more by the fact that they were commissioned than by their positioning of themselves within a field. Instead of presenting extensive literature reviews, EDR writers seem to prefer to use the present tense to provide background information both on their field and specific pertinent details of the project. The following examples (7.150–7.152) from EDR Introduction units illustrate this trend with present tense verbs **bolded**.

7.150 There **are** a variety of new research avenues in thermophysical science and engineering technology development that **require** optical access to high-temperature and high-pressure environments. Applications of these techniques **are contributing** to materials synthesis research, pressurized water reactor studies, and supercritical fluids research. (Introduction Pr1_00_4)

7.151 About a quarter of Alaska's population of 640,000 **live** in isolated villages scattered across the state. More than 118 independent utilities **provide** electricity to Alaska's geographically, economically, and culturally diverse range of communities (Alaska Energy Authority, 2003). Alaska's rugged terrain and lack of roadway systems **make** supplying its rural communities with electricity a challenge. Most of these communities **are powered** by diesel minigrids of up to 3 megawatts (MW) in capacity. (Introduction Pr4_04_2)

7.152 The MESL **consists** of six components: the lower membrane, the upper membrane, membrane sealing materials, the membrane protection, the fill soil, and the wearing surface (Fig. 1). At times the membrane protection and wearing surface **are combined**. The MESL can be constructed with the side membranes exposed, or more commonly (and preferably), with them protected. The MESL in Figure 1a **is** most expedient to construct and **requires** borrow soil. However, its membranes **are** more susceptible to damage and **have** a service life of just a few years or less. (Introduction Pr5_00_2)

The EDR Discussion unit also seems to heavily rely on the use of present tense, both to (a) discuss benefits and impacts of the designed artifact on society and (b) describe the artifact's possible applications. Further, because the results of the genre analysis showed that only 25% of EDR Discussion units include a statement of results, a typical EDR Discussion unit seems to focus on design implications, evaluation, and future project-related activities, all relying on the use of the present tense (**bolded** in excerpts 7.153–7.154).

7.153 Attempting to implement a self-securing storage device with a block device **presents** several problems. Since objects **are** designed to contain one data item (file or directory), enforcing access control at this level **is** more 26 manageable than attempting to properly assign permissions on a per-block basis. In addition, maintaining versions of objects as a whole, rather than having to collect and correlate individual blocks, **simplifies** recovery tools and internal reorganization mechanisms, like the anti-entropy cache. Still, although some of S4's benefits would be lost, we **see** no roadblock to self-securing block-based storage. (Discussion Pr2_00_1)

7.154 Implementation Two: Data Access with Soft Underlayer: In this case, it **is** more illustrative to use the Principle of Reciprocity to describe the information retrieval (reading) [.]. Each cell **includes** a GMR element in a linear region. To identify each layer during the reading process, the sensitivity field of each cell **is varied** via the controlled variation of the "softness" of the SUL on the bottom of the medium. The "softness" **can be controlled** via variation of biasing of the SUL.

The variation of biasing **is produced** by a relatively small electric current (-100 mA turn) through a wire underneath the SUL. This method was developed by PI during the development of perpendicular magnetic recording at Seagate Research [27]. A schematic diagram showing the mechanism of biasing the SUL **is shown** in Figure 13a. The SUL system **consists** of top and bottom layers connected with each other magneto statically and isolated electrically. Due to the magnetostatic coupling, the top and bottom layers of the SUL system **have** magnetization in opposite directions. Due to the well-defined magnetic loop around the biasing wire it **takes** a fairly small electric current (and thus relatively small power loss) to saturate the entire system. As a result, just via relatively small variation of the electric current through the biasing system, one **can** drastically **change** the effective permeability of the SUL and consequently drastically **change** the sensitivity function of each cell. (Pr2_04_1)

The EDR units that rely on the use of the past tense the most are the R&D, Recommendations, Executive Summary, and Results units. In these units, the past tense (**bolded** in excerpts 7.155–7.156) is used most frequently to report methodological procedures and describe the outcomes of these procedures and the design project overall.

7.155 The first attempt at driving the motor **was** with discrete 0.010-inch diameter solid copper insulated wires **bonded** to the PZT using a Ciba-Geigy conductive epoxy. The resonance in the wires **coupled** with thebrittleness of the conductive epoxy **caused** these connections to break the epoxy bonds when the motor **was run**. One variation that **worked** relatively well **involved** threading 0.010-inch diameter **insulated** copper wire through holes in the web of the stator before conductive epoxy bonding the wires to the PZT ceramic. With this configuration, the motors **ran** a long time without failures at room temperature. (Some failures **were noted** in the epoxy bonds during **elevated** temperature testing.) **Based** on the lessons **learned** from the finite element analysis and the relative success of motors **made** by threading 0.010-inch diameter copper wire through the large holes in the stator web, two motors **were made** by threading insulated 0.005-inch diameter solid copper wire through a series of closely **spaced** holes **placed** in the stator web. By keeping the unsupported length of the wire short, this method **was** successful at eliminating the resonances in the leads. This **was confirmed** by testing using the scanning laser Doppler vibrometer. (Executive Summary Pr1_00_2)

7.156 Literature and laboratory analyses **were undertaken** to identify modification requirements of a Cummins Westport, Inc. (CWI) B Gas Plus natural gas engine for H/CNG use in a transit bus application. Previous studies indicate that H/CNG mixtures with 20 to 30 vol% hydrogen are optimal for performance and emissions in existing engine designs. Necessary hardware modifications **included** changing the fuel flow sensor on the engine and increasing on-board fuel storage. Four transit buses, two fueled with CNG and two fueled with H/CNG, **were operated** and **monitored** for 24,000 in-service miles with the SunLine transit fleet in

Thousand Palms, CA. Additionally, chassis dynamometer emission testing of the four buses **was completed.** (Executive Summary Pr4_05_1)

Figure 7.7 and EDR unit examples presented above demonstrate that perfect and progressive aspect verbs are not very common in any of the EDR units.

7.3.7 Modals

Figure 7.8 shows the distribution of modals in professional EDRs units. Surprisingly, no clear pattern can be observed in terms of the prevalence of a particular class of the modal across EDR units. As can be seen, prediction modals are very common in some EDR units while possibility modals are used most frequently in other units. Necessity modals are the least common class across most EDR units, though it is fairly frequent in Recommendations unit.

The units displaying the most frequent use of modals (i.e., Recommendations, Discussion, and Conclusion) involve discussions of possible future project-related activities. In particular, professional EDR writers use modals, both overall and in all three individual classes, to a much greater extent in the Recommendations unit than in any other EDR unit. In the Discussion unit, professional EDR writers show preference for the use of prediction modals whereas possibility modals are very common in the EDR Conclusion unit.

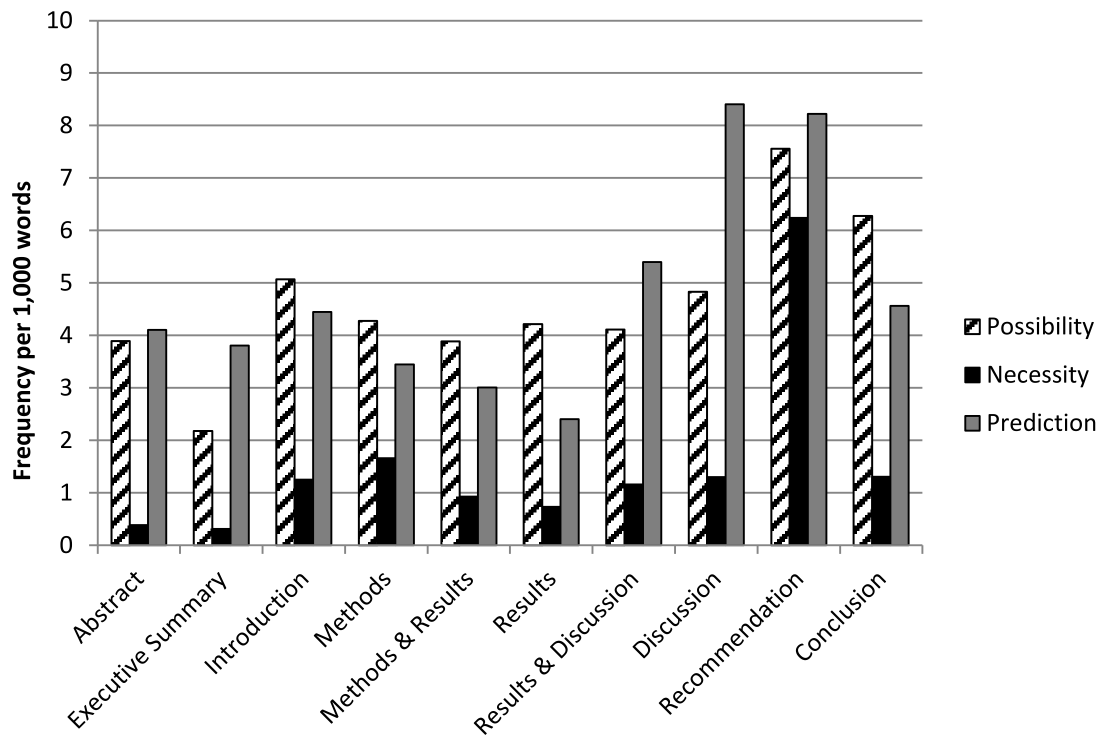


Figure 7.8 Distribution of modals across EDR organizational units

Prediction modals are especially common in the EDR Discussion unit, contributing to the very high density of modals overall in this unit. The modal *will* is especially common in the Discussion unit, but the modal *would* is also used rather frequently. In most cases, *will* is used to refer to future actions or events, for example, when highlighting benefits brought about by the designed artifact (**bolded** in 7.157). Conversely, the modal *would* is typically used to describe hypothetical situations in the future, which may or may not occur (**bolded** in 7.158).

7.157 The increased drying rates **will enable increased machine speed** or elimination of several existing dryers, providing space for a new press section. For new applications it is estimated that the new dryers **will require only 60% as much floor space** as conventional equipment. Increased drying rates **will lead to increased dryer speed**. Multiport dryer technology, when used for new dryer applications, **will play an important role** in realizing the vision of advanced papermaking technologies, including high-speed machines of the future. (Discussion Pr1_01_1)

7.158 The water **would not only be treated** for arsenic, but also pathogens (using, for example, UV treatment) and other chemical contaminants, enhancing the perception of treated water quality (strategy 4). Users **would pay** a small fee for the safe drinking water that they collect from the treatment centre, but due to the low-cost of ARUBA the fee **would remain affordable** to those living on less than US$2 a day (strategy 6) and **would be enough** to cover both the capital and operating costs of the treatment centre. (Discussion Pr1_09_3)

The Conclusion unit differs from the Discussion unit in that prediction modals here are used less frequent than possibility modals *can*, *could*, and *may*. *Can* is the modal most commonly used in the Conclusion unit, typically to express ability meanings (**bolded** in 7.159–7.160, 7.162). *May* is the second most frequent modal used in the Conclusion unit. Unlike can, the modal *may* is generally used to denote possibility meanings (**bolded** in 7.161–7.162). As excerpts below demonstrate, both *can* and *may* tend to occur with inanimate subjects (<u>underlined</u>).

7.159 Self-securing storage ensures data and audit log survival in the presence of successful intrusions and even compromised host operating systems. Experiments with the S4 prototype show that self-securing storage devices **can achieve** performance that is comparable to standard storage appliances. In addition, analysis of recent workload studies suggest that complete version histories **can be kept** for several weeks on state-of-the-art disk drives. (Conclusion Pr2_00_1)

7.160 By varying only $C\mu$ and/or $C\tau$, all the aircraft's aerodynamic characteristics (forces and moments) **can be augmented** or **reduced** as desired by the Super-STOL aircraft's pilot or it's control system without mechanical moving parts (such as tilting rotors or wings) and without resorting to high α to acquire larger vertical thrust components for lift. The blown channel wing itself, without thrust applied, was able to double the C_{Lmax} capability of the baseline aircraft configuration, and multiply its lift at α=0 by a factor of 10. Addition of blowing on the outboard CCW section **can increase** this further, and **can** also **add** drag as needed for Super-STOL approaches. (Conclusion Pr3_04_1)

7.161 Advances to the SLAM algorithm have been made since the early testing described in this paper that allow <u>input of the EKF data and output GPS position</u>, which **may facilitate** a more useful and reliable navigation system. (Conclusion Pr2_06_1)

7.162 While a <u>single test device</u> that **can successfully emulate impacts** with the wide variety of surfaces found in commercial transport aircraft would be advantageous, <u>narrowing the focus of the device’ s usage</u> **may be necessary** to achieve a useful level of correlation. (Conclusion Pr2_04_3)

As one would expect, the Recommendations unit shows the highest density of modals, with all three classes of modals being used almost equally frequently. While both prediction and possibility modals are very common in Recommendations, it is the use of necessity modals that makes this EDR unit most interesting. In fact, necessity modals are used almost six times more frequently in the Recommendations unit than in any other EDR unit. Further, this extremely frequent use of necessity modals in the EDR Recommendations unit is accounted for by the use of *should* only, since no occurrences of *must* were found in the corpus. Predictably, in this unit, *should* is used most frequently to provide advice for possible future design improvements (**bolded** in 7.163–7.165). Another modal verb that is extremely common in the Recommendations unit is *would*, which is typically used to describe future actions and events that could occur (**bolded** in 7.166). It must be noted, however, that the Recommendations unit corpus contained only five texts, which makes it problematic to generalize these findings.

7.163 In the future, the existing model or larger 3-D models **should be modified** to include blown tail surfaces and additional improvements to the pneumatic thrust deflection system. The following **should be** experimentally **investigated**. (Recommendations Pr3_04_1)

7.164 Thus it is anticipated that a 300ºC tool **should minimize the need** for seals. Seals that **cannot** readily **be eliminated should** probably **be backed up** by metallic seals. (Recommendations Pr1_09_1)

7.165 If there had been time for a complete tool redesign, it **should have been possible** to eliminate the bolt penetrations holding the instrument package. An objective in the design of a 300ºC tool **should be to eliminate** as many bolt penetrations as possible as well as other connections and holes. (Recommendations Pr1_09_1)

7.166 Our conclusion is that integrating the TTE protocol **would be straightforward**. Indeed, it is anticipated that the task **would be easier** than the work required to accommodate IEEE 1394, and much cheaper, too. TTE technology already enjoys inexpensive, commercially available hardware and software suitable for prototyping, hosting, and testing. Backwards compatibility with standard Ethernet hardware and software tools **would** also **facilitate** and **reduce the cost** of test equipment, drivers, IP cores, programming and debugging environments, and demonstration systems. TTE **would**, therefore, **make a nice addition** to the URTM protocol suite. (Recommendations Pr3_09_2)

It appears that professional EDR writers use modals the most in the units that conclude the report (i.e., Discussion, Recommendations, and Conclusion). This is not surprising because in these organizational units, the description of the project typically moves beyond the specifics of the procedures and results towards the project's broader goals. As such, EDR writers find themselves interpreting project outcomes, explaining significance and impact of these outcomes, making projections about design artifact's future applications, and providing advice for future work on similar design projects. Certainly, these discussions call upon the frequent use of modals. Similar to the results of the analysis of most lexico-grammatical features in this study, the patterns of distribution of modals across EDR units show both quantitative and qualitative differences, with specific classes of modals being used more frequently in particular EDR units and with individual modals within those EDR units being used more commonly for specific communicative purposes.

7.4. Summary

The results of the genre analysis demonstrate that there is a great deal of variation in the rhetorical organization of EDRs, both in the EDR overall structure and in the structure of EDR organizational units. At a more general level of the overall structure, the two most frequent organizational patterns (A – IMRC and A – I[MR]C) account for only slightly more than a third of the professional EDR corpus. Subsequent move analyses of eight identified EDR organizational units revealed that professional EDRs consist of 12 common moves that seem to cluster in specific ways to form EDR organizational units. In general, certain moves were found to be more frequent and therefore more conventional than others in particular units. Further, moves in each unit tend to occur in particular sequences.

The results of the linguistic analyses of EDR organizational units point out the varied nature of professional discourse. In particular, the analyses in this chapter have shown that linguistic variation exists across professional EDR units and that these differences (and similarities) in EDR writers' use of grammatical features are related to the communicative purposes of EDR units and their constituent moves. For example, individual organizational units have shown different distribution patterns of agentless passives, with the merged R&D unit relying on the use of these structures much more frequently than the Discussion unit. In fact, the EDR units that show the highest density of agentless passives are units that report procedures (Methods unit), results (Results and R&D units), or both (M&R unit), suggesting these units share communicative purposes.

In addition to these quantitative differences across EDR units, the results of the analyses also point towards qualitative differences in the use of specific lexico-grammatical features. For instance, not only are certain semantic classes of verbs used considerably more or less frequently in different EDR organizational units, but even when different organizational units rely on the same semantic class of verbs, individual verbs belonging to this semantic class can be used in distinct ways across these units.

Together the results of the genre and corpus-based register analyses of professional EDRs reported in this chapter result in a simplified template of the EDR discourse structures that includes a description of linguistic features associated with these structures. Table 7.29 summarizes these major findings of the chapter by presenting (a) common organizational units of professional EDRs and their frequent moves and (b) linguistic features that occur most and least frequently in these organizational units. The results of the study may have pedagogical implications for teaching features of professional engineering written discourse to engineering students. The next chapter considers the results of the three types of analysis (i.e., situational, register, and genre) used in this dissertation study and described in Chapters 3, 6, and 7.

Table 7.29 Major organizational units of typical professional EDRs and linguistic features associated with these units

Common EDR organizational units and their most frequent moves (moves in parentheses are optional)	Linguistic features associated with common EDR organizational units
Abstract	**Most frequent:** nouns, nominalizations, occurrence verbs, communication verbs, progressive tense, perfect tense **Least frequent:** necessity modals, mental verbs
Introduction 1. Background 2. Need for project 3. (Previous work) 4. Current design	**Most frequent:** present tense **Least frequent:** agentless passives, activity verbs, aspectual verbs, past tense
Methods 1. (Background) 2. Procedures 3. (Description of Materials: Physical) 4. (Description of Materials: Functional)	**Most frequent:** 3rd parson pronouns, *by*-passives **Least frequent:** occurrence verbs
Methods and Results 1. (Background) 2. Procedures/Testing Procedures 3. (Description of Materials: Physical) 4. Results 5. Problems Encountered 6. Optimization and Troubleshooting / (Follow-Up Activities)	**Most frequent:** mental verbs, *by*-passives **Least frequent:** verbs, causative verbs, communication verbs, occurrence verbs, aspectual verbs
Results 1. Testing Procedures 2. Results 3. Problems Encountered 4. Optimization and Troubleshooting	**Most frequent:** mental verbs, 1st person pronouns **Least frequent:** prediction modals, verbs, causative verbs, communication verbs, occurrence verbs, present tense, perfect aspect, progressive aspect
Discussion 1. (Follow-Up Activities) 2. Implications	**Most frequent:** prediction modals, verbs, aspectual verbs, activity verbs, present tense **Least frequent:** past tense, agentless passive
Conclusions 1. Summary	**Most frequent:** nominalizations, 1st person pronouns, adjectives **Least frequent:** communication verbs, 3rd person pronouns

Note: Parentheses indicate optional organizational units and moves.

CHAPTER 8. CONCLUSIONS

This chapter concludes the present study by synthesizing the findings from the three complimentary types of linguistic analysis – situational, genre, and register – carried out on representative corpora of student and professional engineering design reports (EDRs). The three analyses presented in this dissertation have uncovered complex relationships among situational characteristics of EDRs, their rhetorical structures, and patterns of linguistic variation. The chapter begins with the summary of key findings, focusing on patterns of variation that appear to be associated with specific situational characteristics of EDRs written in professional and academic settings. Next, the multifaceted relationship between rhetorical structures comprising professional EDRs and their linguistic characteristics are discussed. Pedagogical implications of this research are then presented in Section 8.2. Section 8.3 concludes this dissertation with the discussion of study limitations and future directions of this research.

8.1. Summary of Findings

The present dissertation research is the first study that has examined rhetorical structures and linguistic features of the engineering design report, a common engineering genre in both academic and professional settings. The first objective of this study was to (a) investigate the distribution of core lexico-grammatical features in student and professional EDRs and (b) examine how non-linguistic factors influence linguistic variation in these two engineering registers. The second aim of the study was to explore rhetorical structures and core lexico-grammatical features of EDRs written in professional settings.

Two representative EDR corpora were compiled for the purposes of the present study, the student corpus consisting of 185 EDRs written in senior engineering design courses and the professional corpus containing 77 EDRs written for governmental sponsoring agencies. To examine the linguistic variation between professional and student EDRs, all EDRs were 'tagged' for parts of speech and semantic categories using the Biber tagger. Rates of occurrence were then calculated for each linguistic feature by using the Biber tagcount program, which produces normalized counts of 120 grammatical or semantic features per single file based on tags provided by the Biber tagger. The situational characteristics of EDRs were analyzed by using the analytical framework of situational characteristics developed for the present research and validated through surveys and semi-structured interviews with practicing engineers and engineering faculty.

To provide a more comprehensive picture of the EDR genre, the study further examined rhetorical structures and linguistic features of professional EDRs by combining qualitative genre-based and quantitative register-based analyses. Specifically, the genre analysis of professional EDRs entailed the development of a coding scheme, selection and training of two coders, and subsequent coding of organizational units and moves in all professional EDRs in the corpus by at least the researcher and one coder. The results of the genre analysis were then used to inform the linguistic analysis, which was carried out on ten corpora, each representing a major EDR organizational unit. This section of Chapter 8 presents major findings of these investigations, focusing on patterns of linguistic variation that appear to be associated with situational characteristics of EDRs written in professional and academic settings.

Throughout this dissertation research, a complex picture of linguistic variation in EDRs has been uncovered. Although frequently this variation appears to be influenced by multiple factors, non-linguistic factors examined during the situational analysis have been shown to play an important role in shaping the rhetoric and language of the EDR genre. In fact, the situational analysis revealed that despite the apparent proximity of EDRs written in academic and professional settings, these two registers share only a few situational characteristics. The most prominent differences found between student and professional EDRs are related to pedagogical objectives for assigning EDRs in engineering courses and the lack of such objectives in the workplace. In academic settings, EDR writers are expected to display information known in the field and demonstrate a general understanding of the field. Despite these expectations of engineering faculty, student EDRs lack extensive explanations of evidence and procedures because student writers seem think that their descriptions provide general information which does not need to be further explained.

Professional EDR writers, on the other hand, primarily write EDRs to demonstrate deep knowledge of a narrow subfield, advance knowledge of company's engineers and make company more efficient, and distribute innovative technical information early in the information flow process, leading these practitioners to writing more extensive explanations. Even with more in-depth explanations of evidence and procedures, professional EDRs were found to be more concise than student reports. In part, this finding can be attributed to the reported longer periods of planning, drafting, and revising while writing EDRs in the workplace, when compared to the time students spent on EDR writing in academic settings. The conciseness of professional EDRs, however, can also be explained by the results of the linguistic analysis.

The analysis of core lexico-grammatical features of EDRs written in academic and professional settings has revealed complex patterns of linguistic variation. One of the encouraging findings of the study is that the overall patterns of use of most linguistic features examined in the present study were found to be similar in student and professional EDRs, suggesting that engineering students in upper-division undergraduate design courses are learning to emulate engineering discourse, if not yet perfectly.

Another interesting finding of the study, albeit somewhat expected, is that the two EDR registers fill different positions on the spoken-to-written continuum, with reports produced in the workplace being closer to professional written registers and student reports using more speech-like features. In particular, the heavy reliance of student EDR writers on such features as verbs, pronouns, and modals, typically associated with clausal elaboration preferred by spoken rather than written registers, results in more narrative, less information-dense EDRs. On the other hand, professional EDRs showed more frequent use of nouns, adjectives, prepositions, and nominalizations associated with compressed information-packed academic and professional written prose. Practicing engineers also use more varied and sophisticated vocabulary as indicated by the higher type/token ratio, frequency of nominalizations, and longer average word length found in professional EDRs. Combined together, these features point towards a greater overall grammatical complexity of professional EDRs.

The results of linguistic comparisons of student and professional EDRs suggest that practicing engineers have a better sense of their audience's needs and typically produce more effective reports, though the quality of writing was not assessed in this study for either of the two corpora. Because professional EDRs were assumed to be more effectively written, however, their rhetorical structures and linguistic features of were examined further by using two complementary analyses, the qualitative genre-based and quantitative register-based analyses. The results of the genre analysis demonstrate that there is a great deal of variation in the rhetorical organization of EDRs, both in the structure of EDR organizational units and in the EDR overall structure. At a level of EDR organizational units, only a few moves were found in at least 75% of the unit corpora and can be considered obligatory. At a more general level, most EDR organizational units were not observed consistently throughout professional EDRs, with only the Introduction and Conclusion units found in over 80% of the EDR professional corpus. Due to this variable nature of the EDR overall structure, even obligatory moves associated with less pervasive organizational units are used less frequently, thus resulting in further variability in the rhetorical organization of EDRs. These findings suggest that the EDR may not be a well-defined and developed genre.

Despite the variable structure of the EDR genre, the study has resulted in a simplified EDR model to provide support for novice EDR writers and their instructors. The model is based on the results of move analyses of eight EDR organizational units, which revealed that professional EDRs consist of 12 typical moves, some of which can be used in multiple units. In general, certain moves were found to be more frequent and therefore more conventional than others in particular units. Further, moves in each unit tend to occur in particular sequences. For instance, the Introduction unit most frequently consists of the following sequence of moves: Background – Need for Project – Current Project.

The results of the linguistic analyses of EDR organizational units have shown that linguistic variation exists across professional EDR units and that these differences (and similarities) in EDR writers' use of lexico-grammatical features are related to the communicative purposes of EDR units and their constituent moves. In addition to these quantitative differences across EDR units, the results of the linguistic analyses also point towards qualitative differences in the use of specific lexico-grammatical features. Together the results of the genre and register analyses of professional EDRs provide a streamlined template of EDR discourse structures and describe linguistic features associated with them.

8.2. Pedagogical Implications

Overall, it seems that the comprehensive picture emerging from the results of the study is more complex than in most previous studies on engineering discourse, and could be useful for the preparation of instructional materials about discipline-specific written discourse for engineering students. For example, technical writing classes for future engineers may need to emphasize the fact that professional EDR writers frequently rely on the use of nominalizations and complex noun phrases, including pre- and postnominal modifiers, such as prepositional phrases and attributive adjectives.

Next, the highly variable structure of the EDR genre, both the EDR overall structure and the structure of EDR organizational units, calls for more explicit instruction of this genre to novice writers. The insights from this study into how professional EDRs are constructed can greatly facilitate reading and writing tasks in upper-division university engineering courses. In particular, the simplified rhetorical model of the EDR genre presented in this study can provide a starting point for engineering students, both native speakers and non-native speakers of English, who are just starting to be enculturated into professional engineering discourse and may not be particularly efficient readers or writers of EDRs. Being familiar with common EDR organizational units and moves can ease the task of writing EDRs and allow students to focus on content of the design project while at the same time organizing their work in a way that is generally accepted by the engineering discourse community.

Engineering undergraduates can also benefit from authentic models of EDRs that illustrate not only frequent rhetorical structures but also highlight prevalent linguistic features within them. The results of the present study reveal complex patterns of linguistic variation across EDR organizational units. These results can be used to inform pedagogical materials designed for engineering students by presenting pervasive linguistic features of EDR organizational units within the context of their use, thus helping to narrow the gap between students' preparation and professional requirements for succeeding in the workplace.

8.3. Study Limitations and Future Directions

The results of the study should be taken with caution because the study has a number of limitations. First, the professional corpus of EDRs was collected from publicly available databases of governmentally sponsored research and development efforts. Although extensive genre confirmation procedures utilized in the study confirmed that these documents, in fact, belong to the EDR genre, EDRs written in other settings, for instance for internal purposes within private engineering companies, may reveal other situational and linguistic characteristics. With a professional corpus that includes EDRs written in other professional settings, future research of EDRs would certainly gain additional insight about rhetorical structures and linguistic variation within this genre.

Second, for the situational analysis, the study employed a small sample size of participants in both settings, twelve practicing engineers in the workplace and four engineering faculty members. Further, research participants from only one engineering company and one university took part in this analysis, which makes it hard to generalize findings to other engineering companies or engineering university programs in other universities. Future research may want to address this shortcoming by involving a larger number of (a) practicing engineers from engineering companies of different sizes and specializations and (b) engineering faculty from several educational institutions who teach a variety of upper-division courses in different engineering departments. Next, although there is a strong tradition of using survey instruments to examine individual's perceptions and opinions on a variety of subjects, self-reports have disadvantages because of possible social desirability effects (Tremblay, 2001). Future research with additional measurement methods can test the extent of these limitations.

Third, the linguistic analyses in this dissertation included a wide range of linguistic features, but the study of EDRs might advance further from including features that better match this specialized register. Specifically, semantic categories of words used in the study were assigned according to their most common use, which was determined by looking at a range of spoken and written texts (Biber, 2006a). However, because the EDR register is highly specialized, it is entirely possible that words would carry different primary meanings based on their use in EDRs. Future research of the EDR register may reveal previously overlooked variation by including semantic sets of words that are individualized to this specific domain of language use. Further, the linguistic analyses in the present study could be expanded to include additional linguistic features. Specifically, the results of the linguistic analyses pointed towards a prominent role of features associated with structural compression of information-dense academic and professionally written prose. Much more detailed studies of these features, including finite and nonfinite relative clauses, adjectives and nouns as nominal pre-modifiers, and prepositional phrases as noun post-modifiers, would likely add to our understanding of EDRs written in professional settings and of the nature of structural compression in professional engineering writing.

Fourth, although every effort has been made to ensure validity and reliability of genre analysis procedures, including (a) discussions of the coding scheme categories with engineering faculty, (b) selection and training of the two engineering expert coders, and (c) coding of the entire professional EDR corpus by at least two coders, the study did not entail traditional inter-coder reliability procedures. Future studies would benefit from further confirming the results of the organizational unit and move identification by following conventional inter-rater reliability procedures and assessing inter-rater agreement rate using the percentage agreement or Cohen's kappa values. Including coders without engineering expertise could also provide further insight to future research.

Fifth, because of the exploratory nature of the current EDR genre analysis, the coding of typical moves could only be carried out at a rather general level. This level of generality allowed the researcher to paint a broad picture of the rhetorical organization of EDRs and resulted in lower levels of disagreement among coders. However, a more fine-grained, traditional approach to move analysis, which includes the identification of both moves and steps forming particular moves, could translate into additional insights that may have pedagogical implications for teaching engineering students about effective EDRs.

Sixth, despite the previously reported extensive use of visuals in EDRs (Miller et al., 1998), the analyses undertaken in this study did not consider the use of figures and tables in student and professional EDRs. Future studies of EDRs may benefit from taking into consideration the expectation of a divided EDR readership, where some readers will only read the linguistic elements of the document (i.e., the predominantly prose portion of the document), and others will only look over the visuals. It would also be interesting to examine differences and similarities in the use of data commentary (i.e., text accompanying the visuals) by student and professional EDR writers.

Seventh, while every effort was made to account for disciplinary variation, this endeavor proved rather challenging. Specifically, the two engineering experts' opinions about the engineering discipline(s) with which particular artifacts were most closely associated, and, in turn, with which discipline(s) the EDR itself was most closely aligned, often did not match. With much interdisciplinarity in engineering, this outcome was not unexpected, and an "unclear" category was created for all EDRs assigned to undetermined engineering disciplines. This category, in fact, became the largest in the study, comprising 37.5% of the EDRs in professional corpus. This outcome made it difficult to pinpoint the effects of disciplinary variation. Future research would benefit from including EDRs whose disciplinary orientation is clearer.

Finally, based on the results of the genre analysis, the study proposed models representing typical EDR organizational units. Although the findings of the genre analysis present valuable information that can be used by educators working with engineering students who write EDRs, the use of the models presented in the study was not piloted in academic settings. If the genre analysis findings were to be shared with engineering students and faculty, it might be worth considering reformatting the current models after piloting different manners of presentation in engineering courses (as in Stoller & Robinson, 2013).

REFERENCES

Accreditation Board for Engineering and Technology (ABET). (2007). Criteria for accrediting engineering programs. Effective for evaluations during the 2007–2008 accreditation cycle. Retrieved September 23, 2008, from www.abet.org

Accreditation Board for Engineering and Technology (ABET). (2010). Criteria for accrediting engineering programs. Effective for evaluations during the 2010–2011 accreditation cycle. Retrieved March 15, 2010, from www.abet.org

Accreditation Board for Engineering and Technology (ABET). (2013). Criteria for accrediting engineering programs. Effective for evaluations during the 2013–2014 accreditation cycle. Retrieved April 2, 2013, from www.abet.org

Akorede, M. F. (2009). Guidelines for writing an engineering undergraduate project. *IEEE Potentials*, *28*(6), 10–15.

Aktas, R., & Cortes, V. (2008). Shell nouns as cohesive devices in published and ESL student writing. *Journal of English for Academic Purposes, 7,* 3–14.

Amare, N., & Brammer, C. (2005). Perceptions of memo quality: A case study of engineering practitioners, professors, and students. *Journal of Technical Writing and Communication*, *35*(2), 179–190.

American National Corpus. (2007). Known bugs and caveats. Retrieved November 20, 2008, from http://americannationalcorpus.org/SecondRelease/bugs.html

American Society of Engineering Education (ASEE). (1955). Report of the Committee on Evaluation of Engineering Education. *Journal of Engineering Education*, *44*(9), 25–60.

Anthony, L. (1999). Writing research article introductions in software engineering: How accurate is a standard model? *IEEE Transactions on Professional Communication*, *42*(1), 38–46.

Artemeva, N. (1998). The writing consultant as cultural interpreter: Bridging cultural perspectives on the genre of the periodic engineering report. *Technical Communication Quarterly*, *7*(3), 285–299.

Artemeva, N. (2004). Key concepts in rhetorical genre studies: An overview. *Technostyle*, *20*(1), 3–38.

Artemeva, N., Logie, S., & St-Martin, J. (1999). From page to stage: How theories of genre and situated learning help introduce engineering students to discipline-specific communication. *Technical Communication Quarterly*, *8* (3), 301–316.

Askehave, I., & Swales, J. M. (2001). Genre identification and communicative purpose: A problem and a possible solution. *Applied Linguistics*, *22*(2), 195–212.

ATLAS.ti. Version 6.2. [Computer software] (1999). Berlin, Scientific Sofware Development.

Baake, K. (2007). Decision-making in a quasi-rational world: Teaching technical, narratological, and rhetorical discourse in report writing. [Electronic version]. *IEEE Transactions on Professional Communication, 50*(2), 163–171.

Baird, F., Moore, C. J., & Jagodzinski, A. P. (2000). An ethnographic study of engineering design teams at Rolls-Royce Aerospace. *Design Studies*, *21*, 333–355.

Bandyopadhyay, A. (2006). Writing in the discipline – A case study in construction management. *American Society for Engineering Education.* Retrieved January 19, 2008, from http://asee.org/acPapers/code/getPaper.cfm?paperID=10130

Barbieri, F. (2008). Patterns of age-based linguistic variation in American English. *Journal of Sociolinguistics*, *12*(1), 58–88.

Bartholomew, B. (1993). A descriptive framework for identifying schematic elements and patterns in certain science and engineering reports. (Unpublished doctoral dissertation). New York University.

Beams, D. M., & Niiler, L. P. (2004). Improving technical writing through published standards: The University of Texas at Tyler electrical engineering laboratory style guide. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

Beer, D., & McMurrey, D. (1997). *A guide to writing as an engineer*. New York: John Wiley & Sons.

Bhatia, V. K. (1993). Analysing genre: Language use in professional settings. London, U.K.: Longman.

Bhatia, V. K. (1996). Methodological issues in genre analysis. *Hermes, Journal of Linguistics*, *16*, 39–59.

Bhatia, V. K. (1997). The power and politics of genre. *World Englishes, 16*(3), 359–371.

Bhatia, V. K. (2001). Analysing genre: Some conceptual issues. In M. Hewings (Ed.), *Academic writing in context: Implications and applications* (pp. 79–92). Edgbaston, Birmingham, UK: University of Birmingham Press.

Bhatia, V. K. (2002). Applied genre analysis: A multi-perspective model. *Iberica*, 4, 3–19.

Bhatia, V. K. (2004). *Worlds of written discourse: A genre-based view*. New York, NY: Continuum.

Bhatia, V. K. (2006). Discursive practices in disciplinary and professional contexts. *Linguistics and the Human Sciences*, *2*(1), 5–28.

Biber, D. (1988). *Variation across speech and writing*. Cambridge: Cambridge University Press.

Biber, D. (1993). Representativeness in corpus design. *Literary and Linguistic Computing*, *8*(4), 243–257.

Biber, D. (1995). Dimensions of register variation: A cross-linguistic perspective. Cambridge: Cambridge University Press.

Biber, D. (2003). Compressed noun phrase structures in newspaper discourse: The competing demands of popularization vs. economy. In J. Aitchison, & D. Lewis (Eds.), *New media language* (pp. 169–181). London: Routledge.

Biber, D. (2006a). University language: A corpus-based study of spoken and written registers. Amsterdam: John Benjamins.

Biber, D. (2006b). Stance in spoken and written university registers. *Journal of English for Academic Purposes*, *5*, 97–116.

Biber, D., & Clark, V. (2002). Historical shifts in modification patterns with complex noun phrase structures: How long can you go without a verb? In T. Fanego, M. López-Couso, & J. Pérez-Guerra (Eds.), *English historical syntax and morphology* (pp. 43–66). Amsterdam: John Benjamins.

Biber, D., Connor, U., & Upton, T. A. (2007). Discourse on the move: Using discourse analysis to describe discourse structure. Amsterdam: John Benjamins.

Biber, D., Conner, U., Upton, T. A., Anthony, A., & Gladkov, K. (2007). Rhetorical appeals in fundraising. In D. Biber, U. Connor, & T. A. Upton (Eds.), *Discourse on the move: Using discourse analysis to describe discourse structure* (pp. 121–152). Amsterdam: John Benjamins.

Biber, D., Conner, U., Upton, T. A., & Jones, J. (2007). Vocabulary-based discourse units in biology research articles. In D. Biber, U. Connor, & T. A. Upton (Eds.), *Discourse on the move: Using discourse analysis to describe discourse structure* (pp. 175–211). Amsterdam: John Benjamins.

Biber, D., Conner, U., Upton, T. A., & Kanoksilapatham, B. (2007). Introduction to move analysis. In D. Biber, U. Connor, & T. A. Upton (Eds.), *Discourse on the move: Using discourse analysis to describe discourse structure* (pp. 23–41). Amsterdam: John Benjamins.

Biber, D., & Conrad, S. (2009). *Register, genre and style*. Cambridge: Cambridge University Press.

Biber, D., Conrad, S., & Reppen, R. (1998). *Corpus linguistics: Investigating language structure and use*. Cambridge: Cambridge University Press.

Biber, D., & Gray, B. (2010). Challenging stereotypes about academic writing: Complexity, elaboration, explicitness. *Journal of English for Academic Purposes*, *9*, 2–20.

Biber, D., Johansson, S., Leech, G., Conrad, S., & Finegan, E. (1999). *The Longman grammar of spoken and written English*. London: Longman.

Biber, D., & Jones, J. (2005). Merging corpus linguistic and discourse analytic research goals: Discourse units in biology research articles. *Corpus Linguistics and Linguistic Theory*, *1*(2), 151–182.

Biber, D., & Jones, J. (2008). Quantitative methods in corpus linguistics. In A. Lüdeling, & M. Kytö (Eds.), *Corpus linguistics: An International handbook* (pp. 1286–1304). Berlin: Walter de Gruyter.

Blair, G. M., & Robinson, C. M. (1995, February). Professional skills for first-year engineering students. *IEEE Engineering Science and Education Journal*, 4(1), 23–28.

Bloch, J. (2010). A concordance-based study of the use of reporting verbs as rhetorical devices in academic papers. *Journal of Writing Research*, *2*(2), 219–244.

Bowden, J. (2004). Writing a report. How to prepare, write, and present effective reports. Begbroke, UK: How to Books.

Bowker, L., & Pearson, J. (2002). Working with specialized language: A practical guide to using corpora. New York, NY: Routledge.

Braine, G. (1989). An analysis of the writing tasks of undergraduate courses in the natural sciences and engineering. (Unpublished doctoral dissertation). The University of Texas, Austin.

Braine, G. (1995). Writing in the natural sciences and engineering. In D. Belcher & G. Braine (Eds.), *Academic writing in a second language: Essays on research and pedagogy* (pp. 113–134). Norwood, NJ: Ablex.

Brett, P. (1994). A genre analysis of the results section of sociology articles. *English for Specific Purposes*, *13*, 47–59.

Brinkman, G. W., & van der Geest, T. M. (2003). Assessment of communication competencies in engineering design projects. *Technical Communication Quarterly*, *12*(1), 67–81.

Brocato, J., Harden, J., & Chapman, B. (2005). Improving the writing-evaluation abilities of graduate teaching assistants in ECE labs. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/events/conferences/search.cfm

Bruce, I. (2008). Cognitive genre structures in Methods sections of research articles: A corpus study. *Journal of English for Academic Purposes*, *7*, 38–54.

Butler, D. (1987). Government projects and teaching the technical proposal. *Technical Writing Teacher*, *14*(1), 44–51.

Chang, C-F., & Kuo, C-H. (2011). A corpus-based approach to online materials development for writing research articles. *English for Specific Purposes*, *30*, 222–234.

Charles, M. (2003). 'This mystery ...': a corpus-based study of the use of nouns to construct stance in theses from two contrasting disciplines. *Journal of English for Academic Purposes, 2*, 313–326.

Charles, M. (2006). Phraseological patterns in reporting clauses used in citation: A corpus-based study of theses in two disciplines. *English for Specific Purposes*, *25*, 310–331.

Charles, M. (2007). Reconciling top-down and bottom-up approaches to graduate writing: Using a corpus to teach rhetorical functions. *Journal of English for Academic Purposes*, *6*, 289–302.

Chen, Q., & Ge, G. (2007). A corpus-based lexical study on frequency and distribution of Coxhead's AWL word families in medical research articles (RAs). *English for Specific Purposes*, *26*, 502–524.

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

Chiang, Y. D., & Schmida, M. (1999). Language identity and language ownership: Linguistic conflicts of first-year university writing students. In L. Harklau, K. M. Losey, & M. Siegal (Eds.), *Generation 1.5 meets college composition: Issues in the teaching of writing to U.S.-educated learners of ESL* (pp. 81–99). Mahwah, NJ: Lawrence Erlbaum.

Chung, T., & Nation, I. S. P. (2003, October). Technical vocabulary in specialised texts. *Reading in a Foreign Language, 15*(2), 103–116.

Chung, T., & Nation, I.S.P. (2004). Identifying technical vocabulary. *System*, *32*(2), 251–263.

Conrad, S. (1996). Academic discourse in two disciplines: Professional writing and student development in biology and history. (Unpublished doctoral dissertation). Northern Arizona University, Flagstaff.

Conrad, S. (2001). Variation among disciplinary texts: A comparison of texts and journal articles in biology and history. In S. Conrad, & D. Biber (Eds.), *Variation in English: Multi-dimensional studies* (pp. 94–107). London: Longman.

Conrad, S., & Levelle, K. R. (2008). Corpus linguistics and second language instruction. In B. Spolsky, & F. M. Hult (Eds.), *The handbook of educational linguistics* (pp. 539–556). Malden, MA: Blackwell.

Cope, B., & Kalantzis, M. (Eds.). (1993). *The powers of literacy: A genre approach to teaching literacy*. London: Falmer Press.

Cortes, V. (2004). Lexical bundles in published and student disciplinary writing: Examples from history and biology. *English for Specific Purposes, 23,* 397–423.

Crookes, G. (1986). Towards a validated analysis of scientific text structure. *Applied Linguistics*, *7*(1), 57–70.

Csomay, E. (2002). *Episodes in university classrooms: A corpus-linguistic investigation*. (Unpublished doctorate dissertation). Northern Arizona University, Flagstaff.

Csomay, E. (2007). Vocabulary-based discourse units in class sessions. In D. Biber, U. Connor, & T. A. Upton, *Discourse on the move: Using discourse analysis to describe discourse structure* (pp. 213–238). Amsterdam: John Benjamins.

Dalton, D. F. (2008). The foreign language engineering writer – what makes a readable report? *Proceedings of the 2008 American Society for Engineering Education*

Annual Conference & Exhibition. Retrieved May 6, 2010, from http://www.asee.org/about/events/conferences/search.cfm

Daniell, B., Figliola, R., Moline, D., & Young, A. (2003). Learning to write: Experiences with technical writing pedagogy within a mechanical engineering curriculum. *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/events/conferences/search.cfm

Dias, P., & Paré, A. (2000). *Transitions: Writing in academic and workplace settings*. Cresskill, NJ: Hampton Press.

Dominick, P. G., Demel, J. T., Lawbaugh, W. M., Freuler, R. J., Kinzel, G. L., & Fromm, E. (2001). *Tools and tactics of design*. Danvers, MA: John Wiley & Sons.

Dressen, D. F. (2002). *Accounting for fieldwork in three areas of modern geology: A situated analysis of textual silence and salience*. (Unpublished doctoral dissertation). The University of Michigan, Ann Arbor.

Driskill, L. (2000, June). Linking industry best practices and EC3(g) assessment in engineering communication. *Proceedings of the 2000 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/ events/conferences/search.cfm

Dudley-Evans, T. (1994). Genre analysis: An approach to text analysis for ESP. In M. Coulthard (Ed.), *Advances in written text analysis* (pp. 219–228). London, England: Routledge.

Dym, C. L. (1994). *Engineering design. A synthesis of views*. New York, NY: Cambridge University Press.

Eder, W. E., & Hosnedl, S. (2008). *Design engineering: A manual for enhanced creativity.* Boca Raton, FL: Taylor and Francis.

Eggert, R. J. (2005). *Engineering design.* Upper Saddle River, NJ: Pearson Education.

Eide, A. R., Jenison, R. D., Mashaw, L. H., & Northup, L. L. (2002). *Introduction to engineering design and problem solving*. New York, NY: McGraw-Hill.

Ertas, A., & Jones, J. C. (1996). *The engineering design process.* New York, NY: John Wiley & Sons.

Finkelstein, L. (2005). Pocket book of technical writing for engineers and scientists. New York: McGraw-Hill.

Flowerdew, J. (1993, Spring).). Variation across speech and writing in biology: A quantitative study. *Perspectives, (City University of Hong Kong),* 5. Retrieved March 15, 2006, from http://hkjo.lib.hku.hk/archive/files/ca97d37dc4a8ac5f95f9c054c26f044b.pdf

Flowerdew, J., & Peacock, M. (2001). Issues in ESP: A preliminary perspective. In J. Flowerdew & M. Peacock (Eds.), *Research perspectives on English for Academic Purposes* (pp. 8–24). Cambridge, UK: Cambridge University Press.

Flowerdew, J., & Wan, A. (2006). Genre analysis of tax computation letters: How and why tax accountants write the way they do. *English for Specific Purposes*, *25*(2), 133–153.

Flowerdew, J., & Wan, A. (2010). The linguistic and the contextual in applied genre analysis: The case of the company audit report. *English for Specific Purposes*, *29*, 78–93.

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

Flowerdew, L. (2001, August). Corpus linguistics in ESP: A genre-based perspective. In A. Furness, G. Wong, & L. Wu (Eds.), *Penetrating discourse* (pp. 21–35). Language Centre, Hong Kong University of Science and Technology. Retrieved November 16, 2004, from http://repository.ust.hk/dspace/handle/1783.1/1047?mode=full

Flowerdew, L. (2004). The problem-solution pattern in apprentice vs. professional technical writing: An application of appraisal theory. In G. Aston, S. Bernardini, & D. Stewart (Eds.), *Corpora and language learners* (pp. 125–135). Amsterdam: John Benjamins.

Flowerdew, L. (2008). Corpus-based analyses of the problem–solution pattern: A phraseological approach. Amsterdam: John Benjamins.

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

Ford, Y. B. (2009). *Talking about patients: Nurses' language use during hands-off.* (Unpublished doctoral dissertation). The University of Michigan, Ann Arbor.

Freedman, A., & Adam, C. (2000). Write where you are: Situating learning to write in university and workplace settings. In P. Dias, & A. Paré (Eds.), *Transitions: Writing in academic and workplace settings* (pp. 31–60). Cresskill, NJ: Hampton Press.

Freedman, A., & Medway, P. (Eds.). (1994). *Genre and the new rhetoric*. London: Taylor & Francis.

Friginal, E. (2008). *The language of outsourced call centers: A corpus-based study of cross-cultural interaction.* (Unpublished doctoral dissertation). Northern Arizona University, Flagstaff.

Friginal, E. (2009). The language of outsourced call centers: A corpus-based study of cross-cultural interaction. Amsterdam: John Benjamins.

Garland, J., Duerden, S., Helfers, C., & Evans, D. L. (1999). Teaching engineering students their own discourse. *Proceedings of the 1999 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

Gassert, J. D., & Enderle, J. D. (2008, March/April). Design versus research in BME accreditation. *IEEE Pulse: A Magazine of the IEEE Engineering in Medicine and Biology Society*, 80–85.

Glushko, R. J., & McGrath, T. (2005). Document engineering: Analyzing and designing documents for business informatics and Web services. Cambridge, MA: The MIT Press.

Gosden, H. (1992). Discourse functions of marked theme in scientific research articles. *English for Specific Purposes, 11,* 207–224.

Gray, B. E. (2011). Exploring academic writing through corpus linguistics: When discipline tells only part of the story. (Unpublished doctoral dissertation). Northern Arizona University, Flagstaff.

Grey Literature International Steering Committee (GLISC). (2007). *Guidelines for the production of scientific and technical reports: How to write and distribute grey literature. Version 1.1.* GLISC. Retrieved June 23, 2010, from http://www.glisc.info/nancy1.1.pdf

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

Guffey, M. E. (2004). *Essentials of business communication* (6th ed.). Mason, OH: Thomson South-Western.

Hales, C. (1993). *Managing engineering design*. Essex, UK: Longman.

Halliday, M. A. K. (1994). *An introduction to functional grammar* (2nd ed.). London: Edward Arnold.

Hanson, J. H., & Williams, J. (2004). Developing writing-to-learn assignments for the engineering statics classroom. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 10, 2006, from http://www.asee.org/about/events/conferences/search.cfm

Harwood, N. (2005). 'We do not seem to have a theory…the theory I present here attempts to fill this gap': Inclusive and exclusive pronouns in academic writing. *Applied Linguistics, 26*(3), 343–375.

Hayes, J., & Hatch, J. (1999). Issues in measuring reliability. *Written Communication*, *16*(3), 354–367.

Heisler, S. I. (1998). The Wiley engineer's desk reference: A concise guide for the professional engineer. New York, NY: John Wiley & Sons.

Helt, M. (2001). A multi-dimensional comparison of British and American spoken English. In S. Conrad, & D. Biber (Eds.), *Variation in English: Multi-dimensional studies* (pp. 171–184). London: Longman.

Henderson, A., & Barr, R. (2010). Comparing indicators of authorial stance in psychology students' writing and published research articles. *Journal of Writing Research*, *2*(2), 245–264.

Hewings, M., & Hewings, A. (2002). “It is interesting to note that...”: A comparative study of anticipatory ‘it’ in student and published writing. *English for Specific Purposes, 21,* 367–383.

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. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 10, 2006, from http://www.asee.org/about/events/conferences/search.cfm

Hopkins, A., & Dudley-Evans, T. (1988). A genre-based investigation of the discussion sections in articles and dissertations. *English for Specific Purposes*, *7*, 113–122.

Hordemann, G. J. (2003). *Engineering design reports and presentations*. *An introduction*. Ann Arbor, MI: XanEdu Original Works.

Hunston, S. (2008). Collection strategies and design decisions. In A. Lüdeling, & M. Kytö (Eds.), *Corpus linguistics: An International handbook* (pp. 154–168). Berlin: Walter de Gruyter.

Hyland, K. (1996). Writing without conviction? Hedging in science research articles. *Applied Linguistics, 17*(4)*,* 433–454.

Hyland, K. (1998). Boosting, hedging and the negotiation of academic knowledge. *Text, 18,* 349–382.

Hyland, K. (2000). Disciplinary discourses: Social interactions in academic writing. Harlow: Pearson Education.

Hyland, K. (2001). Humble servants of the discipline? Self-mention in research articles. *English for Specific Purposes*, *20*, 207–226.

Hyland, K. (2002). Authority and invisibility: authorial identity in academic writing. *Journal of Pragmatics*, *34*, 1091–1112.

Hyland, K. (2004). Graduates’ gratitude: The generic structure of dissertation acknowledgements. *English for Specific Purposes*, *23*, 303–324.

Hyland, K. (2006). Disciplinary differences: Language variation in academic discourses. In K. Hyland, & M. Bondi (Eds.), *Academic discourse across disciplines* (pp. 17–45). Bern: Peter Lang.

Hyland, K. (2007a). Applying a gloss: Exemplifying and reformulating in academic discourse. *Applied Linguistics, 28(2),* 266–285.

Hyland, K. (2007b). Genre pedagogy: Language, literacy and L2 instruction. *Journal of Second Language Writing*, *16*, 148–164.

Hyland, K. (2008). As can be seen: Lexical bundles and disciplinary variation. *English for Specific Purposes, 27,* 4–21.

Hyland, K., & Bondi, M. (Eds.). (2006*). Academic discourse across disciplines*. Bern: Peter Lang.

Hyman, B. (2003). *Fundamentals of engineering design.* Upper Saddle River, NJ: Pearson Education.

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

Jacoby, S., Leech, D., & Holten, C. (1995). A genre-based developmental writing course for undergraduate ESL science majors. In D. Belcher & G. Braine (Eds.), *Academic writing in a second language: Essays on research and pedagogy* (pp. 113–134). Norwood, NJ: Ablex.

Jenkinson, L.R., & Marchman III, J. F. (2003). *Aircraft design projects for engineering students*. Burlington, MA: Elsevier Science.

Kain, D. & Wardle, E. (2005). Building context: Using activity theory to teach genre in multi-major professional communication courses. *Technical Communication Quarterly*, *14*(2), 113–139.

Kanoksilapatham, B. (2003). A corpus-based investigation of scientific research articles: Linking move analysis with multidimensional analysis. (Unpublished doctoral dissertation). Georgetown University, Washington, DC.

Kanoksilapatham, B. (2005). Rhetorical structure of biochemistry research articles. *English for Specific Purposes*, *24*, 269–292.

Kanoksilapatham, B. (2007). Rhetorical moves in biochemistry research articles. In D. Biber, U. Connor, & T. A. Upton (Eds.), *Discourse on the move: Using discourse analysis to describe discourse structure* (pp. 73–120). Amsterdam: John Benjamins.

Kanoksilapatham, B. (2012). Structure of research article introductions in three engineering subdisciplines. *IEEE Transactions on Professional Communication, 55*(4), 294–309.

Keck, C. M., & Biber, D. (2004). Modal use in spoken and written university registers: A corpus-based study. In R. Facchinetti, & F. Palmer (Eds.), *English modality in perspective: Genre analysis and contrastive studies* (pp. 3–25). Frankfurt am Main: Peter Lang.

Kedrowicz, A. A., & Kvidal, T. (2005). “I thought it was pretty good”: Student perceptions of communication effectiveness. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/ events/conferences/search.cfm

Khan, A. W., & Raouf, A. (2006). *Standards for engineering design and manufacturing*. Boca Raton, FL: Taylor & Francis.

King, C. J. (2006). Let engineers go to college. *Issues in Science and Technology*, *22*(4), 25–28.

Kliment, S. A. (1998). *Writing for design professionals*. New York, NY: W. W. Norton & Company.

Koester, A. (2010). Building small specialised corpora. In A. O'Keeffe, & M. McCarthy (Eds.), *The Routledge handbook of corpus linguistics* (pp. 66–79). New York, NY: Routledge.

Kotecha, P. (1991). Problem solving and report writing for second language engineering students. *Journal of Technical Writing and Communication*, *21*(2), 165–173.

Koutsantoni, D. (2004). Attitude, certainty and allusions to common knowledge in scientific research articles. *Journal of English for Academic Purposes, 3,* 163–182.

Koutsantoni, D. (2006). Rhetorical strategies in engineering research articles and research theses: Advanced academic literacy and relations of power. *Journal of English for Academic Purposes*, *5*, 19–36.

Krishnan, L. A., & Kathpalia, S. S. (2002). Literature reviews in student project reports. *IEEE Transactions on Professional Communication, 45*(3), 187–197.

Kryder, L. (1999). Mentors, models and clients: Using the professional engineering community to identify and teach engineering genres. *IEEE Transactions on Professional Communication, 42*, 3–109.

Kuo, C. (1999). The use of personal pronouns: Role relationships in scientific journal articles. *English for Specific Purposes, 18,* 121–138.

Kwan, B. (2006). The schematic structure of literature reviews in doctoral theses of applied linguistics. *English for Specific Purposes, 25*, 30–55.

Lee, D., & Chen, S. (2009). Making a bigger deal of the smaller words: Function words and other key items in research writing by Chinese learners. *Journal of Second Language Writing, 18,* 149–165.

Linsky, E., & Georgi, G. (2005). Teaching persuasive writing skills using proposals and cover letters. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

Loudermilk, B. (2007). Occluded academic genres: An analysis of the MBA thought essay. *Journal of English for Academic Purposes, 6,* 190–205.

Luzón, M. J. (2002). A genre analysis of corporate home pages. *LSP and Professional Communication*, *2*(1), 41–56.

Luzón, M. J. (2005). Genre analysis in technical communication. *IEEE Transactions on Professional Communication*, *48*(3), 285–295.

Luzón, M. J. (2009). The use of *we* in a learner corpus of reports written by EFL engineering students. *Journal of English for Academic Purposes*, *8*, 192–206.

Manion, W., & Adams, D. (2005). When less is more: Integrating technical writing instruction in a large, first-year engineering course. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

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

Martin, J. R. (1992). *English text: System and structure*. Amsterdam: Benjamin.

McAlpine, H., Hicks, H.J., Huet, G., & Culley, S. J. (2006). An investigation into the use and content of the engineer's logbook. *Design Studies*, *27*, 481–504.

McClure, C. (1988). The federal technical report literature: Research needs and issues. *Government Information Quarterly*, *5*(1), 27–44.

McEnery, T., & Wilson, A. (2001). *Corpus linguistics: An introduction*. Edinburgh: Edinburgh University Press.

McIsaac, C. M., & Aschauer, M. A. (1990). Proposal writing at Atherton Jordan, Inc. *Management Communication Quarterly, 5*(4), 527–560.

McKenna, B. (1997). How engineers write: An empirical study of engineering report writing. *Applied Linguistics*, *18*(2), 189–211.

McNair, L. D., Norback, J. S., & Miller, B. (2005). Integrating discipline-specific communication instruction based on workforce data into technical communication courses. *Proceedings of the 2005 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

Melles, G. (2003). Critical thinking in ESL for postgraduate engineers: Negotiating a discipline. *English for Specific Purposes World*, *2*(5). Retrieved November 16, 2004, from http://www.esp-world.info/articles_5/Melbourne.htm

Meyer, C. F. (2004). *English corpus linguistics: An introduction*. Cambridge: Cambridge University Press.

Miller, C. R. (1984). Genre as social action. *Quarterly Journal of Speech*, *70*(2), 151–167.

Miller, C. R, & Selzer, J. (1985). Special topics of argument in engineering reports, in L. Odell & D. Goswami (Eds.), *Writing in nonacademic settings* (pp. 309–341). New York: Guilford Press.

Miller, P., Bausser, J., & Fentiman, A. (1998). Responding to technical writing in introductory engineering class. The role of genre and discipline. *Technical Communication Quarterly*, *7*(4), 443–461.

Moore, R., & Strueber, J. V. (2004). Effective writing assignments for technical courses. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/ events/conferences/search.cfm

Motley, R., & Nauda, A. (1988). *Strategies for writing the IR&D report*. International Professional Communication Conference record. Seattle, WA.

Mudraya, O. (2004a, April). The student engineering English corpus. *International Computer Archive of Modern and Medieval English Journal, 28*. Retrieved November 16, 2005, from http://nora.hd.uib.no/icame/ij28/shorter_notices.pdf

Mudraya, O. (2004b). Need for data-driven instruction of engineering English [Electronic version]. *IEEE Transactions on Professional Communication, 47*(1), 65–70.

Mudraya, O. (2006). Engineering English: A lexical frequency instructional model. *English for Specific Purposes*. *25*, 235–256.

Narita, M., Kurokawa, K., & Utsuro, T. (2003). Case study on the development of a computer-based support tool for assisting Japanese software engineers with their English writing needs. *IEEE Transactions on Professional Communication, 46*(3), 194–209.

National Information Standards Organization (NISO). (2005). *Scientific and technical reports – preparation, presentation, and preservation.* Bethesda, MD: NISO Press. Retrieved February 11, 2010, from http://www.niso.org/kst/reports/standards

Nelson, S. (2004). Engineering students writing shortcomings and remediation strategies. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/ events/conferences/search.cfm

Norback, J. S., Sokol, J. S., Forehand, G. A., & Sutley-Fish, B. (2004). Using a Communication Lab to Integrate Workplace Communication into Senior Design. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/ events/conferences/search.cfm

Nwogu, K. (1997). The medical research paper: Structure and functions. *English for Specific Purposes, 16*(2), 119–138.

O'Brien, W. T. (2000). *The acceptability of writing by second language engineering students: Acculturation to a profession*. (Unpublished doctoral dissertation). Concordia University, Montreal, Quebec.

Orr, T. (1999). Genre in the field of computer science and computer engineering [Electronic version]. *IEEE Transactions on Professional Communication, 42*(1), 32–37.

Orr, T. (2003). Introduction to the special issue: Developing language support for nonnative speakers of English in science and engineering [Electronic version]. *IEEE Transactions on Professional Communication, 46*(3), 153–156.

Orr, T. (2006). Introduction to the special issue: Insights from corpus linguistics for professional communication [Electronic version]. *IEEE Transactions on Professional Communication, 49*(3), 213–216.

Ostheimer, M. W., & White, E. M. (2005). Portfolio assessment in an American engineering college. *Assessing Writing*, *10*, 61–73.

Owens, C. L., & Fortenberry, N. L. (2007). A transformation model of engineering education. *European Journal of Engineering Education*, *32*(4), 429–440.

Pahl, G., Beitz, W., Feldhusen, J., & Grote, K. H. (2007). *Engineering design: A systematic approach.* New York: Springer-Verlag.

Paltridge, B. (1994). Genre analysis and the identification of textual boundaries. *Applied Linguistics*, *15*(3), 288–299.

Paradis, J. G., & Zimmerman, M. L. (1997). *The MIT guide to science and engineering communication*. Cambridge, MA: The MIT Press.

Peng, J. (1987). Organizational features in chemical engineering research articles. In T. Dudley-Evans (Ed.), *Genre analysis and ESP* (pp. 79–116). The University of Birmingham: ELR Journal 1.

Pérez-Llantada, C. (2010). The 'Dialectics of Change' as a facet of globalisation: epistemic modality in academic writing. In M. F. Ruiz-Garrido, J. C. Palmer-Silveira & I. Fortanet-Gómez (Eds.), *English for Professional and Academic Purposes* (pp. 25-42), Amsterdam: Rodopi.

Pho, P. D. (2008). Research article abstract in applied linguistics and educational technology: A study of linguistic realizations of rhetorical structure and authorial stance. *Discourse Studies*, *10*(2), 231–250.

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

Poltavtchenko, E. (2009, Fall). Writing practices in upper-division undergraduate engineering courses and in the workplace. Paper completed for ENG 709.

Poltavtchenko, E. (2010a, Spring). Writing practices in upper-division undergraduate engineering courses and in the workplace. Paper completed for ENG 697.

Poltavtchenko, E. (2010b, Fall). Qualifying exam: Writing practices in upper-division undergraduate engineering courses and in the workplace. Paper completed for the Qualifying Exam.

Promsin, P. (2006). An analysis of moves and modality in English engineering abstracts. *NIDA Language and Communication Journal*, *11*(11), 43–61. Retrieved November 15, 2008, from http://www.nida.ac.th/th/lc/

Quaglio, P. (2004). *The language of NBC's Friends: A comparison with face-to-face conversation.* (Unpublished doctoral dissertation), Northern Arizona University, Flagstaff.

Räisänen, C. (1998). *The conference forum as a system of genres.* Göteborg: Gothenburg Studies in English.

Reid, J. M. (1998). "Eye" learners and "ear" learners: Identifying the language needs of international students and U.S. resident writers. In J. M. Reid & P. Byrd (Eds.), *Grammar in the composition classroom* (pp. 3–17). Boston: Heinle & Heinle.

Reid, J. M. (2006). *Essentials of teaching academic writing*. Boston: Houghton Mifflin.

Reimerink, A. (2006). The use of verbs in research articles: Corpus analysis for scientific writing and translation. *New Voices in Translation Studies, 2,* 9–27.

Rhoulac, T. D., & Crenshaw, P. (2006). Preparing civil engineering students to meet workplace writing expectations. *Proceedings of the 2006 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved February 10, 2008, from http://www.asee.org/about/events/conferences/search.cfm

Robinson, C. M., & Blair, G. M. (1995). Writing skills training for engineering students in large classes. *Higher Education*, *30*, 99–114.

Robinson, M. S., Stoller, F. L., Costanza-Robinson, M. S., & Jones, J. K. (2008). *Write like a chemist: A guide and resource*. New York: Oxford University Press.

Rodby, J. (1999). Contingent literacy: The social construction of writing for nonnative English-speaking college freshmen. In L. Harklau, K. M. Losey, & M. Siegal (Eds.), *Generation 1.5 meets college composition: Issues in the teaching of writing to U.S.-educated learners of ESL* (pp. 45–61). Mahwah, NJ: Lawrence Erlbaum.

Roden, M. S., & Murphy, T. E. (2009). Writing and speaking to technical professionals: Communication skills for success. Los Angeles: Discovery Press.

Roozenburg, N. F. M., & Eekels, J. (1995). *Product design: Fundamentals and methods*. West Sussex, UK: John Wiley & Sons.

Rorrer, R. A. L. (2003, August). Credentials for the job: Look at the capstone design report to get a reading on an untried engineer. *Mechanical Engineering*, 50.

Salager-Meyer, F. (1992). A text type and move analysis study of verb tense and modality distribution in medical English abstracts. *English for Specific Purposes*, *11*, 93–113.

Salager-Meyer, F. (1994). Hedges and textual communicative function in medical English written discourse. *English for Specific Purposes, 13*(2), 149–170.

Samraj, B. (2002). Introductions in research articles: variation across disciplines. *English for Specific Purposes*, *21*, 1–17.

Samraj, B. (2005). An exploration of a genre set: Research article abstracts and introductions in two disciplines. *English for Specific Purposes*, *24*, 141–56.

Samraj, B., & Monk, L. (2008). The statement of purpose in graduate program applications: Genre structure and disciplinary variation. *English for Specific Purposes*, *27*, 193–211.

Schneiter, W. (2003). Writing and undergraduate engineers—a continuing problem. *Proceedings of the 2003 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/events/conferences/ search.cfm

Scott, M. (1996). WordSmith Tools (Computer Software). Oxford: Oxford University Press. Available from http://www.lexically.net/wordsmith/

Scott, M. (2004) WordSmith Tools Version 4 (Computer Software). Oxford: Oxford University Press. Available from http://www.lexically.net/wordsmith/

Seliman, S. (1995). *Engineering research presentations: Three units of analysis.* Paper presented at the Annual Meeting of Teachers of English to Speakers of Other Languages, Long Beach, CA.

Shalamova, N. (2008). *Accreditation in a College of Engineering: Rhetoric of self-study reports.* (Unpublished doctoral dissertation). New Mexico State University, Las Cruces.

Shaw, P. (2006). Relations between text and mathematics across disciplines. In K. Hyland, & M. Bondi (Eds.), *Academic discourse across disciplines* (pp. 103–122). Bern: Peter Lang.

Sheehan, R., & Flood, A. (1999). Genre, rhetorical interpretation and the open case: Teaching the analytical report. *IEEE Transactions on Professional Communication*, *42*(1), 20–31.

Shi, L., & Kubota, R. (2007). Patterns of rhetorical organizations in Canadian and American language arts textbooks: An Exploratory Study. *English for Specific Purposes, 26*(2), 180–202.

Shigley J., Mischke, C., & Brown, T. H. (2004). *Standard handbook of machine design*. New York, NY: McGraw-Hill.

Silyn-Roberts, H. (2000). Writing *for science and engineering: Papers, presentations, and reports*. Woburn, MA: Butterworth-Heinemann.

Skelton, J. (1997). The representation of truth in academic medical writing. *Applied Linguistics*, *18*(2), 121–140.

Sloat, E. (1994). *Case studies of technical report writing development among student writers*. (Unpublished doctoral dissertation). McGill University, Montreal, Quebec.

Sokoloff, H. (2003, May 28). Engineers forced to learn how to write [Electronic version]. *National Post*. Retrieved December 1, 2004, from http://www.pegnl.ca/dialogue/issues/ 2003/september_2003/article_10.htm

Sorby, S. A., & Bulleit, W. M. (2006). *An engineering guide to technical communication.* Upper Saddle River: Pearson Prentice Hall.

Spilka, R. (1993). *Writing in the workplace: New research perspectives*. Carbondale: Southern Illinois University Press.

Spinuzzi, C. (2004). Describing assemblages: Genre sets, systems, repertoires, and ecologies. *Computer Writing and Research Lab. White Paper Series.* Retrieved June 20, 2010, from http://www.cwrl.utexas.edu/files/040505-2.pdf

Stoller, F. L., Jones, J. K., Costanza-Robinson, M. S., & Robinson, M. S. (2005). Demystifying disciplinary writing: A case study in the writing of chemistry [Electronic version]. *Language and Learning across the Disciplines, Interdisciplinary Perspectives on Language, Learning, and Academic Writing*. Retrieved January 21, 2007, from http://wac.colostate.edu/atd/lds/stoller.cfm

Stoller, F. L., & Robinson, M. S. (2013). Chemistry journal articles: An interdisciplinary approach to move analysis with pedagogical aims. *English for Specific Purposes, 32*, 45–57.

Storch, N., & Tapper, J. (2000). The focus of teacher and student concerns in discipline-specific writing by university students. *Higher Education Research and Development*, *19*(3), 337–355.

Stotesbury, H. (2006): Gaps and false conclusions: Criticism in research article abstracts across the disciplines. In K. Hyland, & M. Bondi (Eds.), *Academic discourse across disciplines* (pp. 123–48). Bern: Peter Lang.

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

Swales, J. M. (2004). *Research genres: Explorations and applications*. Cambridge: Cambridge University Press.

Swales, J. M., Ahmad, U., Chang, Y., Chavez, D., Dressen, D., & Seymour, R. (1998). Consider this: The role of imperatives in scholarly writing. *Applied Linguistics, 19,* 97–121.

Swales, J. M., & Najjar, H. (1987). The writing of research article introductions. *Written Communication*, *4*, 175–192.

Swarts, J., & Odell, L. (2001, October). Rethinking the evaluation of writing in engineering courses. *Proceedings of the 2001 ASEE/IEEE Frontiers in Education Conference. Reno, NV.*

Sysoyev, P. V. (2000). Developing an English for specific purposes course using a learner centered approach: A Russian experience. *The Internet TESL Journal, 6*(3). Retrieved June, 22, 2005, from http://iteslj.org/Techniques/Sysoyev-ESP.html

Tardy, C. M. (2004). The role of English in scientific communication: Lingua franca or Tyrannosaurus rex?, *Journal of English for Academic Purposes, 3*, 247–269.

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

Terry, J., Ruchhoeft, P., Bannerot, R., & Kastor, R. (2004). A just-in-time model for teaching technical communications in a multidisciplinary capstone design course. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved May 6, 2005, from http://www.asee.org/about/events/conferences/search.cfm

Towler, G., & Sinnott, R. (2008). Chemical engineering design. Principles, practice and economics of plant and process design. Burlington, MA: Elsevier.

Tremblay, P. F. (2001). Research in second language learning motivation: Psychometric and research design considerations. In Z. Dornyei & R. Schmidt (Eds.), *Motivation and second language acquisition* (Technical Report #23, pp. 239–255). Honolulu: University of Hawai'i, Second Language Teaching and Curriculum Center.

Tse, P., & Hyland, K. (2006). Gender and discipline: Exploring metadiscourse variation in academic book reviews. In K. Hyland, & M. Bondi (Eds.), *Academic discourse across disciplines* (pp. 177–202). Bern: Peter Lang.

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

U.S. Army Engineer Research and Development Center (ERDC). (2006). *Guide for preparing technical information reports of the Engineer Research and Development Center*. Vicksburg, MS: ERDC. Retrieved June 23, 2010 from http://www.dtic.mil/cgi-bin/GetTRDoc?Location=U2&doc=GetTRDoc.pdf&AD=ADA445281

Varantola, K. (1983). An aspect of term-formation in engineering English. In H. Ringbom, & M. Rissanen (Eds.), *Proceedings from the Nordic Conference for English Studies*, Hanasaari/Hanaholmen, Finland, May 19–21.

Viel, J. (2002, May). The vocabulary of English for scientific and technological occupational purposes. *English for Specific Purposes World*, *1*(1), Retrieved November 10, 2004, from http://www.esp-world.info/Articles_1/vocabulary.html

Vold, E. T. (2006).The choice and use of epistemic modality markers in linguistics and medical research articles. In K. Hyland, & M. Bondi (Eds.), *Academic discourse across disciplines* (pp. 225–249). Bern: Peter Lang.

Walker, K. (1999). Using genre theory to teach students engineering lab report writing: A collaborative approach. *IEEE Transactions on Professional Communication*, 42(1), 12–19.

Wanted: Leaders who can lead and write. (1997, December). *Workforce*, 21.

Ward, J. (2007). Collocation and technicality in EAP engineering. *Journal of English for Academic Purposes*, *6*, 18–35.

Ward, J. (2009). A basic engineering English word list for less proficient foundation engineering undergraduates. *English for Specific Purposes*, *28*, 170–182.

Wasson, C. S. (2006). System analysis, design, and development: Concepts, principles, and practices. Hoboken, New Jersey: John Wiley & Sons.

Weigle, S. (2002). *Assessing writing*. New York: Cambridge University Press.

Weinstein, E. (1987). Using technical articles to teach technical report writing. *Technical Writing Teacher*, *14*(2), 151–157.

Weissberg, R., & Buker, S. (1990). *Writing up research*. Englewood Cliffs, N.J.: Prentice Hall Regents.

Wenyan, G. (2008). Information packaging in English medical papers published in a Chinese journal. *CELEA Journal, 31*(3), 42–47.

Whalen, T. (1985). A history of specifications: Technical writing in perspective. *Journal of Technical Writing and Communication, 15*, 235–245.

Whalen, T. (1986). A training checklist for engineering proposals. *Technical Writing Teacher*, *13*(1), 18–22.

Wikoff, K., Friauf, J., Tran, H., Reyer, S., & Petersen, O. (2004). Evaluating the communication component of an engineering curriculum: A case study. *Proceedings of the 2004 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

Wild, P. J., Giess, M. D., & MacMahon, C. A. (2009). Describing engineering documents with faceted approaches. Observations and reflections. *Journal of Documentation*, *65*(3), 420–445.

Wilhelm, W. J. (1999). A Delphy study of entry-level workplace skills, competencies, and proof-of-achievement products. *The Delta Pi Epsilon Journal*, *41*, 105–122.

Williams, I. (1999). Results section of medical research articles. *English for Specific Purposes*, *18*, 347–366.

Williams, J. M. (2001). Transformations in technical communication pedagogy: Engineering, writing, and the ABET Engineering Criteria 2000. *Technical Communication Quarterly*, *10*(2), 149–167.

Winsor, D. (1996). *Writing like an engineer: A rhetorical education.* Mahwah, NJ: Lawrence Erlbaum.

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

Winsor, D. (2006). Using writing to structure agency: An examination of engineers' practice. *Technical Communication Quarterly*, *15*(4), 411–430.

Wojahn, P., Dyke, J., Riley, L. A., Hensel, E., & Brown, S. C. (2001). Blurring boundaries between technical communication and engineering: Challenges of a multidisciplinary, client-based pedagogy. *Technical Communication Quarterly*, *10*(2), 129–148.

Yang, R., & Allison, D. (2003). Research articles in applied linguistics: Moving from results to conclusions. *English for Specific Purposes*, *22*, 365–385.

Young, A., & Fulwiler, T. (1986). *Writing across the disciplines: Research into practice*. Upper Montclaire, NJ: Boyton/Cook.

Young, E. F. & Alford, E. M. (1999). Using rhetorical analysis to help undergraduates acquire effective professional writing skills. *Proceedings of the 1999 American Society for Engineering Education Annual Conference & Exhibition.* Retrieved March 15, 2006, from http://www.asee.org/about/ events/conferences/search.cfm

APPENDIX A. INTERVIEW PROTOCOL FOR PRACTICING ENGINEERS

- *Purpose:* The purpose of my project is to collect information about technical reports written in upper-division undergraduate engineering courses and in the workplace. The results of the present study will serve as a preliminary step for my dissertation research which will entail identifying linguistic features, and other features, that characterize effective technical reports written by engineers. The results of this research may have pedagogical implications for teaching features of professional engineering written discourse to students majoring in engineering. The ultimate goal of the proposed research is to narrow the gap between students' preparation and professional requirements for writing successful technical reports in the workplace. It is my hope that my findings will help engineering students advance from novice to professional writing.

- *Definition:* For the purposes of this study, I focus on formal documents that are usually produced in response to a specific request or research need and written after a project has been completed. These reports typically include research about technical concepts as well as graphical depictions of designs and data. They often serve as reports of accountability to funding organizations and are written for the following purposes: (a) to give an overview of how a design, an analysis, or an engineering study was accomplished, (b) to provide a thorough description of all useful technical work completed for the project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a project. Because technical reports are written after a project has been completed, they typically entail a collective effort. In many settings such documents are referred to as **technical reports**.

- This interview is going to be tape recorded. I am assuming you are OK with that?
- The interview consists of approximately 15–18 questions and will take about 20 minutes.

QT1

1) When you hear the term *technical report*, what comes to mind?

a. What are the different kinds of technical reports that you know of?
b. Is a ____________________ actually the formal label used when engineers discuss this type of technical reports?
c. Do they have different labels (i.e., are they called by different names)?

2) What distinguishes these different reports from one another?
3) What technical reports do people in your branch of engineering write?
4) What are the distinguishing characteristics of these technical reports?

5) In general, what are the three main purposes for writing a technical report in an engineering company?
6) In your company, more specifically, what is the main purpose for writing a technical report?

QT2

1) How often do you write technical reports?

If answer is vague, follow with

a. Once a year? Twice a year? More often? Less often?

2) Are there other engineers at your company who write technical reports?

If YES,

3) If so, how often are they expected to write these reports?

If answer is vague, follow with

a. Once a year? Twice a year? More often? Less often?

4) In your company, what other types of documents do you write?

If interview identifies other types of written documents,

5) When compared to these other documents, how often do you write technical reports?
6) Would you say that technical reports are written more frequently or less frequently than these other written documents?
7) Of all these documents, which one is the most important for a successful career in engineering?

QT3

1) What are typical evaluation criteria for technical reports in your company?
2) When a technical report is written for someone outside your company, what are the typical criteria used to evaluate its quality?
3) Are these evaluation criteria typically made known to you when the technical report is requested?
4) In your company, when a technical report is evaluated, which three characteristics of writing are the most important to your company?
5) When technical reports are assessed, does your company use an evaluation form?

If YES,

6) What are the major evaluation criteria included on the form?
7) How are the evaluation criteria weighted?
8) Would you mind sharing a copy of the evaluation form used in your company with me?

-

QT4

1) Could you take a minute to turn the pages of these four reports and tell me if they are, in fact, technical reports and why?
2) Is there anything else that you think I should know about the technical reports written by engineers in your company? Or technical reports in general?

Thank you for your time.

Instructions about the follow-up electronic survey.

- In the next couple of days, I will be sending you a link for the follow-up online survey.
- The survey needs be finished in one approach and should take not more than 10 minutes.
- I am interested in more than what was covered in the interview. So a series of questions in this online the survey will help me to collect more information about situational factors that influence how technical reports are written in academic and professional settings. This information will then help me explain differences in linguistic differences used in technical reports written by students and professional engineers.

APPENDIX B. ONLINE SURVEY QUESTIONS FOR PRACTICING ENGINEERS

Welcome to the survey on disciplinary writing in engineering, with an emphasis on written technical reports. Thank you for taking the time to complete it. The survey should take you about 10 minutes to complete.

DEFINITION: For the purposes of this study, technical reports are broadly defined as documents written after a project has been completed for the following purposes: (a) to give an overview of how a design, an analysis, or an engineering study was accomplished, (b) to provide a thorough description of all useful technical work completed for the project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a project. Because technical reports are written after a project has been completed, they typically entail a collective effort.

PURPOSE: The purpose of this research is to collect information about technical reports written in upper-division undergraduate engineering courses and in the workplace. A series of questions in this online survey will help me to collect information about the situational factors that influence how technical reports are written in academic and professional settings. This information will then help me explain the differences between technical reports written by students and by professional engineers. The ultimate goal of the research is to narrow the gap between students' preparation and professional requirements for writing successful technical reports in the workplace.

1. Author(s) and reader(s)

1.1. Approximately how many technical reports did you write before joining your company?

- (•) 0
- ( ) 1–3
- ( ) 4–6
- ( ) 7–10
- ( ) 11+

1.2. About how many technical reports did you write in your upper-division engineering classes when you were a college student?

- ( ) 0
- ( ) 1–3
- ( ) 4–6
- ( ) 7–10
- ( ) 11+

1.3. At the conclusion of your college experience, how prepared were you for writing technical reports in your company?

- ○ I felt well prepared.
- ○ I felt somewhat prepared.
- ○ I felt somewhat unprepared.
- ○ I felt unprepared.

1.4. In your company, do engineers write technical reports individually or in groups (collaboratively)?

- ○ Individually
- ○ In groups
- ○ Other

1.5. Has your company provided you with any materials on the formatting and style of written technical reports?

- ○ Yes
- ○ No

1.6. What types of materials, if any, have you been provided to assist you in writing your technical reports? (Please check all relevant boxes)

- ☐ Specific information on format of technical reports
- ☐ Specific information on style of technical reports
- ☐ Models of previously written technical reports in full
- ☐ Models of sections of previously written technical reports
- ☐ Technical writing book(s) that include chapter(s) on technical reports
- ☐ None of the above
- ☐ Other

1.7. If sections of technical reports were provided to you as models, which ones were given to you?

1.8. Why do you think these particular sections were selected as models of technical reports?

1.9. Who is the typical audience for the reports you write in your company? (Please check all relevant boxes)

- ☐ My immediate supervisor
- ☐ Engineers in my company
- ☐ Managers in my company
- ☐ Engineers outside of my company
- ☐ Managers outside of my company
- ☐ Clients
- ☐ Funding agencies
- ☐ Other

2. Relationships among author(s) and reader(s)

2.1. In your technical reports, how often do you describe projects that focus on very narrow engineering topics about which your audience may not have a lot of disciplinary knowledge?

- ○ Always
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Never
- ○ Other

3. Setting

3.1. In your company, are you most often asked to write technical reports for external use or internal use?

- ○ External use only
- ○ Internal use only

○ External and internal use
○ Other [ ]

3.2. In general, how do you communicate with the intended readers of the technical reports that you write?

○ In person
○ Electronically
○ Other [ ]

4. Writing process

4.1. On average, how much time do you typically spend writing a technical report?

○ Less than an hour
○ 1–5 hours
○ 6–10 hours
○ 11–20 hours
○ 21–30 hours
○ Other [ ]

4.2. On average, how much time do you spend planning (e.g., brainstorming, outlining) to write a technical report?

○ Less than an hour
○ 1–5 hours
○ 6–10 hours
○ 11–20 hours
○ 21–30 hours
○ Other [ ]

4.3. Typically, when writing technical reports, do you produce more than one draft?

○ Yes
○ No

4.4. When, writing technical reports, how many drafts do you usually write?

- 1–2
- 3–4
- 5+

4.5. On average, how much time do you spend revising your technical reports?

- Less than an hour
- 1–5 hours
- 6–10 hours
- 11–20 hours
- 21–30 hours
- Other

4.6. How often are you provided with an opportunity to rewrite or extensively revise your technical reports after they are returned to you?

- Never
- Rarely
- Sometimes
- Often
- Always
- Other

4.7. In your company, do engineers revise technical reports individually or collaboratively?

- Individually
- Collaboratively
- Other

4.8. What kinds of feedback do engineers working in your company receive on their technical reports, if any?

4.9. Who provides engineers with such feedback? (Please check all relevant boxes)

- ☐ Immediate supervisor(s)
- ☐ Other engineers
- ☐ Collaborators
- ☐ Managers
- ☐ Other

5. Physical layout

5.1. On average, what is the expected length of a typical technical report written by engineers in your company if you exclude cover pages and appendices?

- ○ 1–10 pages
- ○ 11–20 pages
- ○ 21–30 pages
- ○ Other

5.2. What are the typical sections and subsections of a technical report written by engineers in your company? Please list them as they are most often sequenced in reports.

5.3. How important is it for engineers in your company to include these sections and subsections?

- ○ Not at all important
- ○ Somewhat unimportant
- ○ Somewhat important
- ○ Extremely important

- ○ Other [ ]

5.4. How important is it for engineers in your company to adhere to the sequence that you specified above?

- ○ Not at all important
- ○ Somewhat unimportant
- ○ Somewhat important
- ○ Extremely important
- ○ Other [ ]

5.5. What reference style do engineers in your company use to cite sources in their technical reports?

- ○ There is no reference style that I know of.
- ○ APA (American Psychological Association style manual)
- ○ IEEE (Institute of Electrical and Electronics Engineers Standards style manual)
- ○ Other

6. Explanation of evidence

6.1 Select one response for each of the following statements.

	Extensive explanation	Moderate explanation	Limited explanation	No explanation
How much explanation of your original data do you TYPICALLY PROVIDE in your technical reports?	○	○	○	○
How much explanation of your original data are you EXPECTED TO PROVIDE in your technical reports?	○	○	○	○

6.2 Select one response for each of the following statements.

	Extensive review	Moderate review	Limited review	No review
How extensively do you TYPICALLY REVIEW previous research (including your own) in your technical reports?	○	○	○	○
How extensively are you EXPECTED TO REVIEW previous research (including your own) in your technical reports?	○	○	○	○

7. Explanation of procedures

7.1 Select one response for each of the following statements.

	Extensive explanation	Moderate explanation	Limited explanation	No explanation
How much explanation of your procedures do you TYPICALLY PROVIDE in your technical reports?	○	○	○	○
How much explanation of your procedures are you EXPECTED TO PROVIDE in your technical reports?	○	○	○	○

7.2 Which procedures, if any, are considered so basic that they do not need to be explained in your technical reports?

8. Background information

8.1 Because responses provided in the survey must be matched to those in the interview, I need to be able to identify particular survey respondents. Please provide your first and last name in the text box below.

** Note that these personal identifiers will be removed after they are matched with the interview and responses are assembled in a database.*

8.2 Gender

- ◯ Male
- ◯ Female

8.3 Age

- ◯ Under 30
- ◯ 31–35
- ◯ 36–40
- ◯ 41–45
- ◯ 46–50
- ◯ 50+

8.4 Is English your native language?

- ◯ Yes
- ◯ No

8.5 Major in college

[ ]

8.6 Your highest educational degree

- ◯ Associate
- ◯ Bachelor's
- ◯ Master's
- ◯ Doctorate

8.7 Years/months working as an engineer

[ ]

8.8 Your current job title

[ ]

8.9 Which area of engineering do you currently work in? (Please check all relevant boxes)

- ☐ Biomedical engineering
- ☐ Chemical engineering
- ☐ Civil engineering
- ☐ Electrical engineering
- ☐ Industrial engineering
- ☐ Mechanical engineering
- ☐ Other ______

8.10 Do you manage or supervise other engineers?

- ○ Yes
- ○ No

8.11 Do those working for you prepare any technical reports?

- ○ Yes
- ○ No

8.12 Are there any additional remarks that you'd like to make about technical reports and related issues?

8.13 Are you interested in receiving a summary of the research findings?

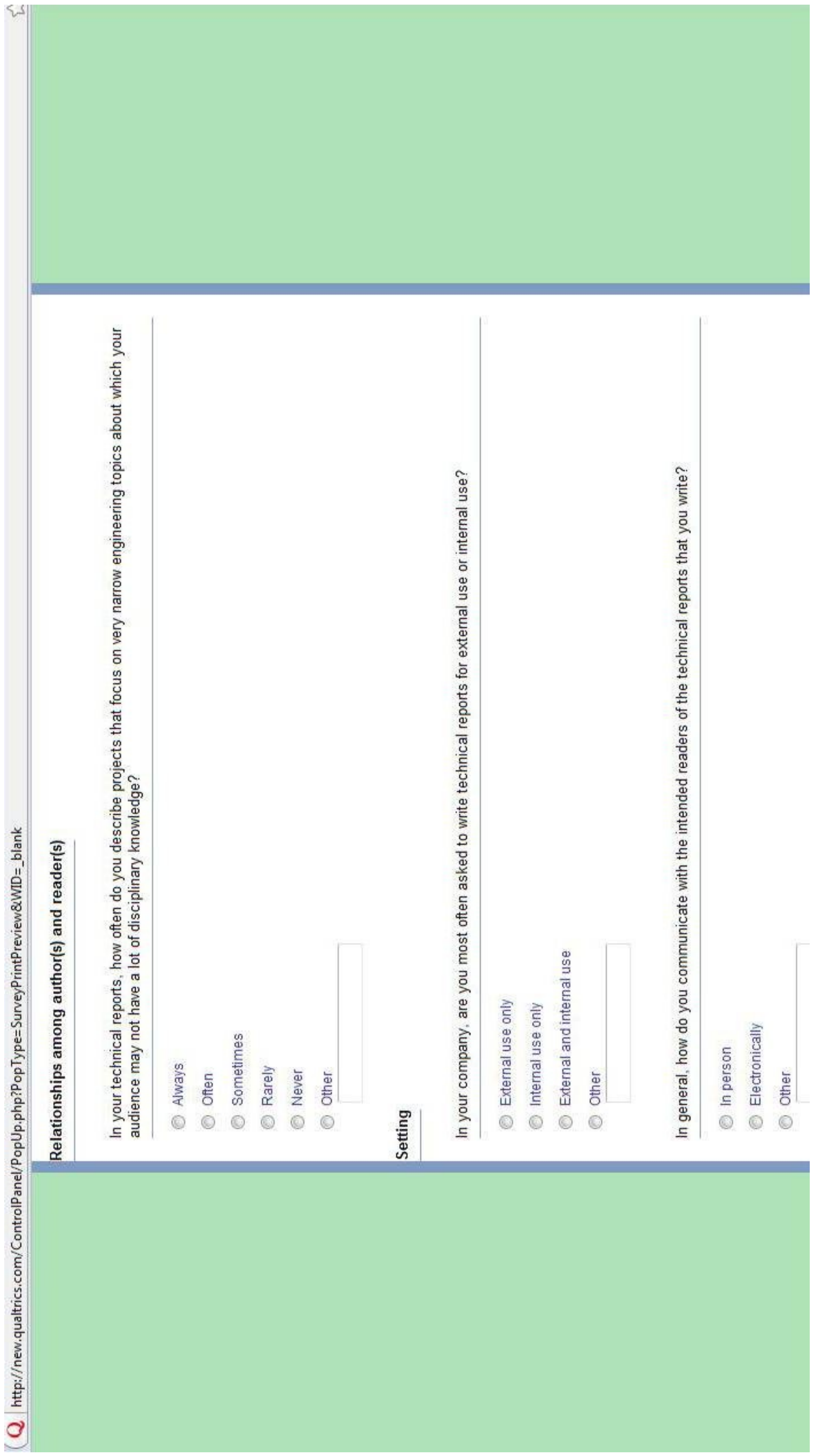
- ○ Yes. Please include your e-mail address. ______
- ○ No

8.14 Would you be willing to participate in some follow-up questions via email?

- ○ Yes. Please include your email address. ______
- ○ No

Thank you for completing the survey. I deeply appreciate your contribution to this important research.

APPENDIX C. SCREENSHOT OF THE ONLINE SURVEY FOR PRACTICING ENGINEERS



http://new.qualtrics.com/ControlPanel/PopUp.php?PopType=SurveyPrintPreview&WID=_blank

Relationships among author(s) and reader(s)

In your technical reports, how often do you describe projects that focus on very narrow engineering topics about which your audience may not have a lot of disciplinary knowledge?

- Always
- Often
- Sometimes
- Rarely
- Never
- Other

Setting

In your company, are you most often asked to write technical reports for external use or internal use?

- External use only
- Internal use only
- External and internal use
- Other

In general, how do you communicate with the intended readers of the technical reports that you write?

- In person
- Electronically
- Other

APPENDIX D. INTERVIEW PROTOCOL FOR ENGINEERING FACULTY

- *Purpose:* The purpose of my project is to collect information about technical reports written in upper-division undergraduate engineering courses and in the workplace. The results of the present study will serve as a preliminary step for my dissertation research which will entail identifying linguistic features, and other features, that characterize effective technical reports written by engineers. The results of this research may have pedagogical implications for teaching features of professional engineering written discourse to students majoring in engineering. The ultimate goal of the proposed research is to narrow the gap between students' preparation and professional requirements for writing successful technical reports in the workplace. It is my hope that my findings will help engineering students advance from novice to professional writing.

- *Definition:* For the purposes of this study, I focus on formal documents that are usually produced in response to a specific request or research need and written after a project has been completed. These reports typically include research about technical concepts as well as graphical depictions of designs and data. They often serve as reports of accountability to funding organizations and are written for the following purposes: (a) to give an overview of how a design, an analysis, or an engineering study was accomplished, (b) to provide a thorough description of all useful technical work completed for the project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a project. Because technical reports are written after a project has been completed, they typically entail a collective effort. In many settings such documents are referred to as **technical reports**.

- This interview is going to be tape recorded. I am assuming you are OK with that?
- The interview consists of approximately 15–18 questions and will take about 20 minutes.

QT1

1) When you hear the term *technical report*, what comes to mind?
   a. What are the different kinds of technical reports that you know of?
   b. Is a ____________________ actually the formal label used when engineers discuss this type of technical reports?
   c. Do they have different labels (i.e., are they called by different names)?

2) What distinguishes these different reports from one another?
3) In which of your upper-division classes do you assign technical reports?
4) What are the main reasons for assigning technical reports in this class/these classes?

5) Which other upper-division university engineering classes that you know of require students to write technical reports?
6) What are the three most important benefits that students gain from writing technical reports?

QT2

1) How often do you assign students in your upper-division engineering classes to write technical reports?
2) What other types of written documents do you assign in your upper-division engineering classes?

If interviewee specifies other types of written documents:
3) In comparison to these other written assignments, how often do you assign students to write technical reports?
4) Would you say that technical reports are assigned more frequently or less frequently than other types of written work?
5) Of all these writing assignments, which one is the most important for students' future careers in engineering?

QT3

1) What are the grading criteria used to evaluate technical reports written for your upper-division engineering classes?
2) Do you make your evaluation criteria known to students?

If yes,
3) When do you share the criteria with your students? When you describe the assignment to students or when you return their work to them with a grade?

4) When you grade technical reports written by your students, which three characteristics of writing are the most important to you?
5) When grading students' technical reports, do you use an evaluation form or rubric?

If YES,
6) Let's talk about your evaluation form. What are the major evaluation criteria included on the form?
7) How are the evaluation criteria weighted?
8) Would you mind sharing a copy of your evaluation form with me?

QT4

1) Could you take a minute to turn the pages of these four reports and tell me if they are, in fact, technical reports and why?
2) Is there anything else that you think I should know about the technical reports written by students in your classes? Or technical reports in general?

Thank you for your time.
Instructions about the follow-up electronic survey.

- In the next couple of days, I will be sending you a link for the follow-up online survey.
- The survey needs be finished in one approach and should take not more than 10 minutes.
- I am interested in more than what was covered in the interview. So a series of questions in this online the survey will help me to collect more information about situational factors that influence how technical reports are written in academic and professional settings. This information will then help me explain differences in linguistic differences used in technical reports written by students and professional engineers.

APPENDIX E. ONLINE SURVEY QUESTIONS FOR ENGINEERING FACULTY

Welcome to the survey on disciplinary writing in engineering, with an emphasis on written technical reports. Thank you for taking the time to complete it. The survey should take you about 10 minutes to complete. Your participation in this project is voluntary, and you may refuse to answer any questions. To safeguard your confidentiality, all personal identifiers (e.g., names of individuals, engineering firms, cities) will be removed from survey responses before they are assembled in a database.

DEFINITION: For the purposes of this study, I focus on formal documents that are usually produced in response to a specific request or research need and written after a project has been completed. These reports typically include research about technical concepts as well as graphical depictions of designs and data. They often serve as reports of accountability to funding organizations and are written for the following purposes: (a) to give an overview of how a design, an analysis, or an engineering study was accomplished, (b) to provide a thorough description of all useful technical work completed for the project, including the rationale for technical decisions, and (c) to provide a permanent, complete, and accurate record of the technical aspects of a project. Because technical reports are written after a project has been completed, they typically entail a collective effort. In many settings such documents are referred to as technical reports.

PURPOSE: The purpose of this research is to collect information about technical reports written in upper-division undergraduate engineering courses and in the workplace. A series of questions in this online survey will help me compile information about the situational factors that influence how technical reports are written in academic and professional settings. This information will then help me explain the differences between technical reports written by students and by professional engineers. The ultimate goal of the research is to narrow the gap between students' preparation and professional requirements for writing successful technical reports in the workplace.

1. Author(s) and reader(s)

1.1. Approximately how many upper-division writing intensive classes do engineering students take before entering your classes?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ Other ____

1.2. About how many times have your students written technical reports <u>before</u> they write a technical report for your classes?

- ○ 0
- ○ 1–2
- ○ 3–4
- ○ 5–6
- ○ Other [ ]

1.3. Generally, how prepared for writing technical reports are students in your upper-division university engineering classes?

- ○ Well prepared
- ○ Somewhat prepared
- ○ Somewhat unprepared
- ○ Unprepared

1.4. Do students typically write technical reports individually or in teams (collaboratively)?

- ○ Individually
- ○ In teams
- ○ Other [ ]

1.5. How many sophomore or freshman students do you see in upper-division classes in which you assign technical reports?

- ○ None
- ○ A few
- ○ About half of the class
- ○ Many
- ○ Other [ ]

1.6. Do you provide your students with any materials on the formatting and style of written technical reports?

- ○ Yes
- ○ No

1.7. What types of materials do you provide your students to help them with their technical reports? (Please check all relevant boxes)

- ☐ Specific information on format of technical reports
- ☐ Specific information on style of technical reports
- ☐ Models of previously written technical reports in full
- ☐ Models of sections of previously written technical reports
- ☐ Technical writing book(s) that include chapter(s) on technical reports
- ☐ None of the above
- ☐ Other

1.8. If you provide your students with models of technical reports, who are the authors of these model reports: students or professionals?

- ○ Students
- ○ Professionals
- ○ Other

1.9. What is your motivation for selecting model technical reports written by these authors?

1.10. If you provide your students with sections of technical reports, which sections do you typically provide as models?

1.11. What is your rationale for selecting these sections as models of technical reports?

1.12. Who is the typical audience for the technical reports written by your students? (Please check all relevant boxes)

- ☐ Professor (teacher of record)
- ☐ Students working on the same project
- ☐ Other students in class
- ☐ Fictitious clients
- ☐ Real clients
- ☐ Funding agency
- ☐ Other ______

1.13. What is your primary rationale for assigning students to write technical reports?

- ○ To provide students with opportunities to learn engineering design concepts
- ○ To provide students with opportunities to successfully communicate their work on the project
- ○ Other ______

2. Relationships among author(s) and reader(s)

2.1. In their technical reports, how often do students describe projects that focus on very narrow engineering topics about which the reader may <u>not</u> have a lot of disciplinary knowledge?

- ○ Always
- ○ Often
- ○ Sometimes
- ○ Rarely
- ○ Never
- ○ Other ______

3. Setting

3.1. In your classes, do students most often write technical reports to satisfy a course requirement or to complete real-life projects?

- ○ To satisfy a course requirement
- ○ To complete real-life projects
- ○ Both to satisfy a course requirement and to complete real-life projects
- ○ Other ______

3.2. On average, how do students communicate with the intended readers of their technical reports?

- In person
- Electronically
- Other [ ]

4. Writing process

4.1. How much time is typically given to students to write a technical report?

- A full semester
- A half of a semester (about 8 weeks)
- A quarter of a semester (about 4 weeks)
- Other [ ]

4.2. On average, how much planning (e.g., brainstorming, outlining) do you think your students put into their work on technical reports?

- Less than an hour
- 1–5 hours
- 6–10 hours
- 11–20 hours
- 21–30 hours
- Other [ ]

4.3. Typically, are students who are writing technical reports asked to produce more than one draft?

- Yes
- No

4.4. How many drafts do students usually write?

- 1–2
- 3–4
- 5+

4.5. On average, how much time do you think your students typically spend revising their technical reports?

- Less than an hour
- 1–5 hours

- 6–10 hours
- 11–20 hours
- 21–30 hours
- Other

4.6. How often are students provided with an opportunity to revise their reports after their reports are returned to them?

- Never
- Rarely
- Sometimes
- Often
- Always
- Other

4.7. When students are given the opportunity to revise their technical reports, do they work on revisions individually or collaboratively?

- Individually
- Collaboratively
- Other

4.8. When students work collaboratively, how do you ensure each student's participation?

4.9. What kinds of feedback, if any, do your students receive on their technical reports?

4.10. Who provides students with such feedback? (Please check all relevant boxes)

- I do (their professor)
- Students' team members
- Other students in class
- Clients

☐ Other [ ]

5. Physical layout

5.1. On average, what is the expected length of a typical technical report written by students in your upper-division university engineering classes if you exclude cover page and appendices?

- ○ 1–10 pages
- ○ 11–20 pages
- ○ 21–30 pages
- ○ Other [ ]

5.2. What are the typical sections and subsections of a technical report written by students in your upper-division university engineering classes? Please list the sections and subsections as they are most often sequenced in students' reports.

[ ]

5.3. How important is it for students to include the sections and subsections mentioned above?

- ○ Not at all important
- ○ Somewhat unimportant
- ○ Somewhat important
- ○ Extremely important
- ○ Other [ ]

5.4. How important is it for students to adhere to the sequence that you specified above?

- ○ Not at all important
- ○ Somewhat unimportant
- ○ Somewhat important
- ○ Extremely important
- ○ Other [ ]

5.5. What reference style do your students use to cite sources in their technical reports?

- ○ There is no specified reference style.
- ○ APA (American Psychological Association style manual)
- ○ IEEE (Institute of Electrical and Electronics Engineers Standards style manual)
- ○ Other [ ]

6. Explanation of evidence

6.1. Select one response for each of the following statements.

	Extensive explanation	Moderate explanation	Limited explanation	No explanation
How much explanation of their original data do your students TYPICALLY PROVIDE in their technical reports?	○	○	○	○
How much explanation of their original data are your students EXPECTED TO PROVIDE in their technical reports?	○	○	○	○

6.2. Select one response for each of the following statements.

	Extensive review	Moderate review	Limited review	No review
How extensively do your students TYPICALLY REVIEW previous research in their technical reports?	○	○	○	○
How extensively are your students EXPECTED TO REVIEW previous research in their technical reports?	○	○	○	○

7. Explanation of procedures

7.1. Select one response for each of the following statements.

	Extensive explanation	Moderate explanation	Limited explanation	No explanation
How much explanation of their procedures do your students TYPICALLY PROVIDE in their technical reports?	○	○	○	○
How much explanation of their procedures are your students EXPECTED TO PROVIDE in their technical reports?	○	○	○	○

7.2. Which procedures, if any, are considered so basic that they do not need to be explained in students' technical reports?

8. Background information on survey respondent

8.1 Because responses provided in the survey must be matched to those in the interview, I need to be able to identify particular survey respondents. Therefore, it is extremely important that you provide your first and last name in the text box below.

** Note that these personal identifiers will be removed after they are matched with the interview and responses are assembled in a database.*

8.2 Gender

- ○ Male
- ○ Female

8.3 Age

- ○ Under 30
- ○ 31–35
- ○ 36–40
- ○ 41–45
- ○ 46–50
- ○ 51+

8.4 Is English your native language?

- Yes
- No

8.5 Major in college

8.6 Your highest educational degree

- Master's
- Doctorate
- Additional degree(s)
- Other

8.7 Years teaching engineering subjects at the university level

8.8 Your rank

- Adjunct lecturer
- Instructor
- Lecturer
- Assistant professor
- Associate professor
- Professor
- Other

8.9 Which area of engineering do you specialize in? (Please check all relevant boxes)

- Biomedical engineering
- Chemical engineering
- Civil engineering
- Electrical engineering
- Industrial engineering
- Mechanical engineering
- Other

8.10 How important is writing for your own career?

- ○ Very unimportant
- ○ Somewhat unimportant
- ○ Somewhat important
- ○ Very important
- ○ Other [ ]

8.11 Have you ever worked as a practicing engineer?

- ○ Yes
- ○ No

8.12 When working as a practicing engineer, did you write technical reports?

- ○ Yes
- ○ No

8.13 Are there any additional remarks that you'd like to make about technical reports and related issues?

[ ]

8.14 Are you interested in receiving a summary of research findings?

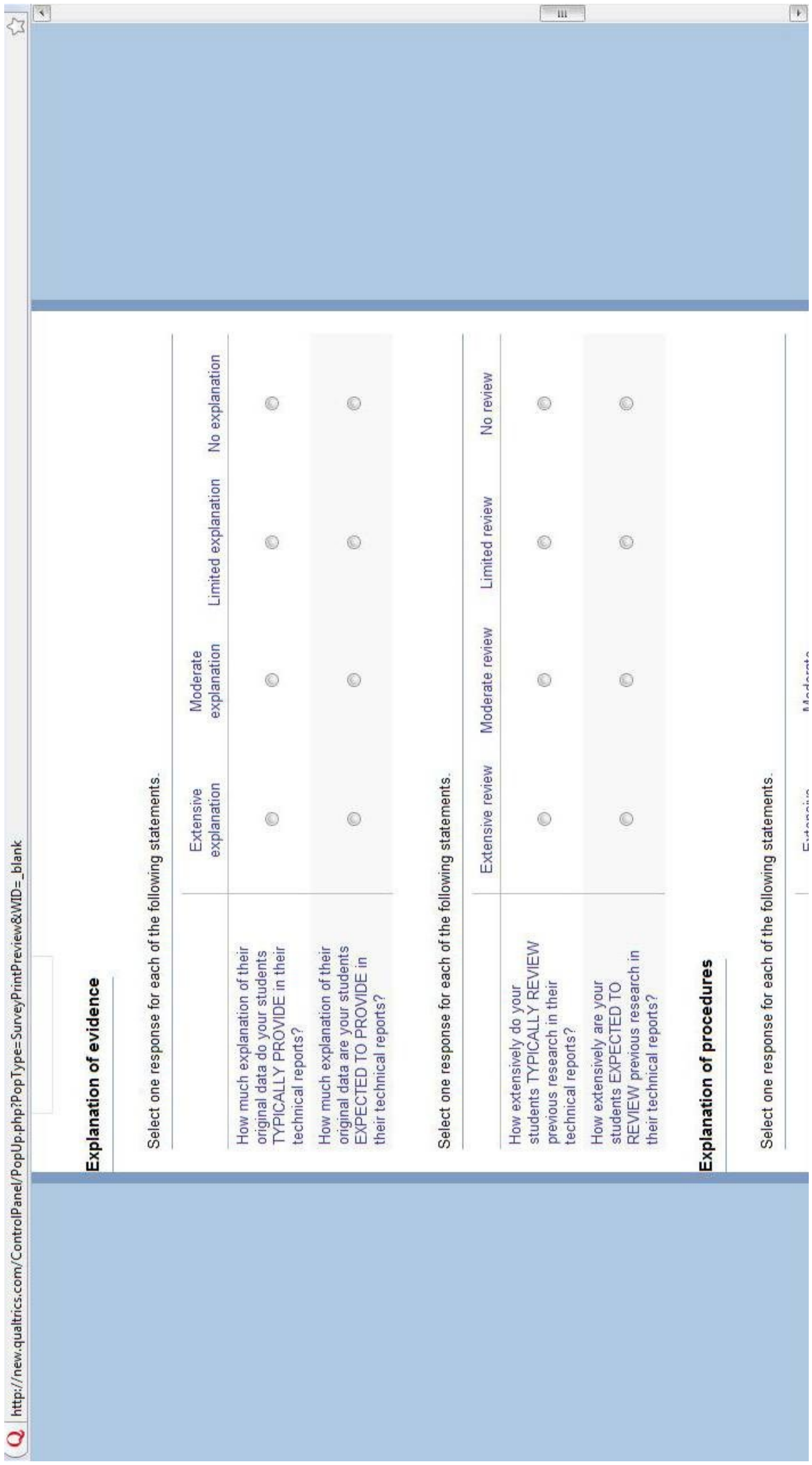
- ○ Yes. Please include e-mail address. [ ]
- ○ No

8.15 Would you be willing to participate in some follow-up questions via email?

- ○ Yes. Please include e-mail address. [ ]
- ◉ No

Thank you for completing the survey. I deeply appreciate your contribution to this important research.

APPENDIX F. SCREENSHOT OF THE ONLINE SURVEY FOR ENGINEERING FACULTY



APPENDIX G. ANALYTICAL FRAMEWORK FOR THE SITUATIONAL ANALYSIS

Parameter 1: Participants

A. Author(s)
1. Single / group / organization / unidentified
2. Level of training in the discipline:
   Professional, newly employed graduate, upper- division student
3. Seniority within an organization or school:
   More than 3 years, 2-3 years, fewer than 2 years

B. Audience
1. Single/ group/ client(s)/ organization (or class) / unidentified
2. Those within an organization (or class)/ those outside of an organization (or class)
3. Level of training in the discipline:
   Professional, upper-division student

C. Guides (i.e., colleagues, mentors, instructors)
1. Primarily evaluators / primarily collaborators
2. Focus on learning/ focus on the written product and success of communication

Parameter 2: Relationship between / among Author(s) and Audience

C. Power differential:
1. Equal
2. High -> Low
3. Low -> High

D. Expected amount of shared disciplinary knowledge:
1. High
2. Medium
3. Low

Parameter 3: Setting

E. Request:
1. By an organization for internal use
2. By an organization for external use
3. By a faculty teaching upper-division engineering class
4. Both 1 and 2
5. Both 1 and 3
6. Both 2 and 3

F. Relation to author's learning needs
1. Related (i.e., writing tasks are carefully sequenced and designed, they are simplified and facilitated)
2. Unrelated (i.e., tasks are focused on material or discursive outcomes and participants are often not focused on the learning that occurs)

G. Place of communication
1. University
2. Workplace

H. Method of communication
1. In person
2. Electronically

Parameter 4: Writing Process

E. Degree of planning:
1. Extensive
2. Moderate
3. Minimal

F. Degree of revision:
1. Extensive
2. Moderate
3. Minimal

G. Time of guidance:
1. Before technical report is completed
2. After technical report is completed

H. Results of guidance:
1. Individual revisions
2. Collaborative effort in revision stages

Parameter 5: Physical Layout

A. Length

B. Organization

C. Reference style used, if any

Parameter 6: Explanation of Evidence

A. Explanation of primary evidence
1. Extensive
2. Moderate
3. Limited
4. None

B. Explanation of secondary evidence
1. Extensive
2. Moderate
3. Limited
4. None

Parameter 7: Explanation of Procedures

A. Explanation of procedures
1. Extensive
2. Moderate
3. Limited
4. None

Parameter 8: Communicative Purpose(s)

A. Overall purpose for writing report:
1. Display information known in field
2. Contribute new knowledge
3. Demonstrate general understanding of the field
4. Demonstrate deep knowledge of a narrow subfield

APPENDIX H. SELECTION CRITERIA FOR ETR DATABASES AND EDRS WITHIN THEM

I. Initial ETR Database Selection Criteria

The database:

1. Should contain documents that are in public domain
2. Should contain documents published in English, in the U.S.
3. Should contain documents published not earlier than 2000
4. Should contain documents that are technical reports (i.e., it is a TR database)
5. Should contain documents that cover one of the sub-disciplines of Engineering (i.e., a database is engineering-oriented)

Database	Public domain	U.S., English	Not earlier than 2000	TR database	Engineering
1. AERADE Reports Archive	+	+	1909–1979	+	+
2. CiteSeerX	+	+	+	No	No
3. Compaq and DEC Technical Reports (HP Labs Database)	+	+	1990–2002	+	No
4. Computer Science Technical Reports at Stanford	+	+	+	+	No
5. Computing Research Repository (CoRR)	+	+	+	No	software engineering
6. Contrails, The Wright Air Development Center Collection	+	+	1950–1960	+	+
7. Department of Energy Data Explorer	+	+	+	No	No
8. Department of Energy EnergyFiles	+	+	+	No	+
9. Department of Energy Information Bridge	+	+	1991–present	+	No
10. Energy Technology Data Exchange (ETDE) World Energy Base	+	not U.S.	1876–present	No	No
11. Engineer Research and Development Center (ERDC)	+	+	+	+	+
12. E-Print Network	+	+	+	No	+
13. Glenn Technical Reports Center (GLTRC NASA)	+	+	+	+	No
14. HP Labs Technical Reports	+	+	1990–present	+	No
15. IBM Research Reports	+	+	+	+	No
16. International Atomic Energy Agency	+	not U.S.	+	+	Subject
17. Lawrence Livermore National Laboratory (LLNL)	+	+	+	+	No
18. McGill Engineering Technical Reports	+	+	1949–1977 1960–present	+	+
19. Microsoft Research Technical Reports	+	not U.S.	+	+	No

Database	Public domain	U.S., English	Not earlier than 2000	TR database	Engineering
20. MIT Center for Advanced Nuclear Energy Systems (CANES)	No	+	1990–present	+	nuclear engineering
21. NASA Technical Reports Server (NTRS)	+	+	*NACA-* 1915–1958 NASA-1958–pres	No	+
22. National Institute of Standards and Technology, Building Fire Research Laboratory (Firedocs)	+	+	1965–present	contract reports	+
23. National Renewable Energy Laboratory (NREL)	+	+	1977–present	No	No
24. National Service Center for Environmental Publications (NSCEP)	+	+	+	No	No
25. National Technical Information Service (NTIS) Database (not free)	No	+	1964–present	No	+
26. Quakeline Database, Information Service of the Multidisciplinary Center for Earthquake Engineering Research (MCEER)	+	+	1987–present	No	+
27. Science.gov Database	+	+	+	No	No
28. Tandem Technical Reports	+	+	1981–1996	+	No
29. TechXtra Database	+	not U.S.	+	No	+
30. Technical Report Archive and Image Library (TRAIL)	+	+	prior to 1975	+	No
31. The Defense Technical Information Center (DTIC)	+	+	1974–present	+	No
32. The Virtual Technical Reports Center	+	+	+	+	No
33. World Resources Institute	+	not U.S.	+	No	No
34. WorldWideScience.org Database	+	not U.S.	+	No	+

Note: Entries in italics did not satisfy at least one of the first three database selection criteria and were eliminated from further review. The entry in bold font signifies the only database that satisfied all selection criteria in the initial list.

II. Modified ETR Database Selection Criteria

The database:

1. Should enable "publication type" search if it is not a TR database
2. Should allow search by a discipline if it is not an engineering database
3. Should enable search by year of publication if it contains reports published earlier than 2000
4. Should contain reports available for download in either .pdf or .doc (rtf, txt) formats

Database	Publication type search	Discipline search	Search by year	Available in .pdf or .doc
1. CiteSeerX	No	No	+	+
2. Compaq and DEC Technical Reports (HP Labs Database)	+	No	+	+
3. Computing Research Repository (CoRR)	No	software, computat.	No	+
4. **Computer Science Technical Reports at Stanford**	+	computer science	+	+
5. Department of Energy Data Explorer	No	+	No	+
6. Department of Energy EnergyFiles	No	+	+	No
7. ***Department of Energy Information Bridge***	+	No	+	+
8. ***Engineer Research and Development Center (ERDC)***	+	engineering database	+	+
9. E-Print Network (Science Accelerator Resource)	No	+	+	No
10. **Glenn Technical Reports Center (GLTRC NASA)**	+	No	+	+
11. **HP Labs Technical Reports**	+	No	+	+
12. IBM Research Reports	+	electrical e, eng. & tech.	No	No
13. **Lawrence Livermore National Laboratory (LLNL)**	+	No	+	+
14. **McGill Engineering Technical Reports**	+	civil, mech.	+	+
15. ***NASA Technical Reports Server (NTRS)***	+	+	+	+
16. National Institute of Standards and Technology, Building Fire Research Laboratory (Firedocs)	grant/ contract reports	engineering/ residual stress	+	+
17. ***National Renewable Energy Laboratory (NREL)***	+	No	+	+
18. National Service Center for Environmental Publications (NSCEP)	No	Subject	+	No
19. Quakeline database, Information Service of the Multidisciplinary Center for Earthquake Engineering Research (MCEER)	+	Subject	+	No
20. Science.gov Database	No	No	+	+
21. ***The Defense Technical Information Center (DTIC)***	+	No	+	+
22. The Virtual Technical Reports Center	+	No	No	No

Note: Entries in bold met at least three of the selection criteria; only those in italics were selected for the study.

APPENDIX I. SOURCES OF STUDENT EDRS

Source	Engineering discipline(s)	Year	Number of EDRs		Total selected
			Rejected	Selected	
Sub-corpus 1 Large private not-for-profit university	EE, COMP, and Neurobiology	2008	4[a]	--	--
Sub-corpus 2 Large public university	Interdisciplinary (EE, COMP, SoftE)	2010	20[b,c]	6	**122**
		2009	21[b,c]	5	
		2008	15[b]	3	
		2007	15[b,c,e]	11	
		2006	10[b,c,e]	21	
		2005	20[b,c,e]	17	
		2004	15[b,c,e]	9	
		2003	17[b,c]	19	
		2002	5[b,e]	19	
		2001	6[b]	8	
		2000	--	4	
Sub-corpus 3 Large public university	EE, ME, CENE	2010		1 EE, 4 ME, 13 CENE	**25**
		2008	1[d]	1 EE	
		2006		1 CENE	
		2005		1 ME	
		2003		2 ME	
		2002		1 ME	
		2001		1 ME	
Sub-corpus 4 Small private, not-for-profit university	General engineering	2005	2[d,e]	12	**24**
		2006	4[d,e]	7	
		2007	1[e]	1	
		2008	6[d,e]	4	
Sub-corpus 5 Large public university	EE	2008	12[b]	--	**--**
		2009	20[b]		
Sub-corpus 6 Large public university	Interdisciplinary (EE, ME, INDU)	2003		14	**55**
		2004		27	
		2005		14	
				TOTAL	**226**

Note: The following abbreviations were used in the table: CENE – civil engineering, COMP – computer engineering, EE – electrical engineering, INDU – industrial engineering, ME – mechanical engineering, SoftE – software engineering.

Reasons for rejection: (a) inclusion of a discipline not represented elsewhere, (b) report on a project that has not been completed, (c) report that is not an EDR (e.g., research report or recommendation report), (d) single-authored report, (e) report that is 50 or more pages long.

APPENDIX J. SIGNIFICANCE TESTING FOR REGISTER-BASED LINGUISTIC ANALYSES

Table J1. ANOVA Results for Comparisons between Professional and Student EDRs ($\alpha = 0.001$)

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
nouns	Between groups	50531.77	1	50531.77	34.44	<.0001
	Within groups	382933.98	261	1467.18		
	Total	433465.75	262			
verbs	Between groups	15124.09	1	15124.09	78.27	<.0001
	Within groups	50431.32	261	193.22		
	Total	65555.41	262			
adjectives	Between groups	19046.94	1	19046.94	101.9	<.0001
	Within groups	48791.80	261	186.94		
	Total	67838.74	262			
adverbs	Between groups	24.17	1	24.17	0.73	ns
	Within groups	8613.37	261	33.00		
	Total	8637.54	262			
abstract nouns	Between groups	148.29	1	148.29	1.28	ns
	Within groups	30259.20	261	115.94		
	Total	30407.50	262			
concrete nouns	Between groups	365.84	1	365.84	4.56	ns
	Within groups	20925.70	261	80.18		
	Total	21291.54	262			
process nouns	Between groups	589.84	1	589.84	17.63	<.0001
	Within groups	8730.85	261	33.45		
	Total	9320.70	262			
quantity nouns	Between groups	208.61	1	208.61	4.4	ns
	Within groups	12384.03	261	47.45		
	Total	12592.64	262			
technical nouns	Between groups	0.31	1	0.31	0.01	ns
	Within groups	11259.85	261	43.14		
	Total	11260.15	262			
animate nouns	Between groups	1243.26	1	1243.26	55.09	<.0001
	Within groups	5890.44	261	22.57		
	Total	7133.70	262			
place nouns	Between groups	6.70	1	6.70	0.35	ns
	Within groups	4959.86	261	19.00		
	Total	4966.56	262			
cognition nouns	Between groups	14.90	1	14.90	3.94	ns
	Within groups	987.10	261	3.78		
	Total	1001.99	262			
group nouns	Between groups	1.02	1	1.02	0.25	ns
	Within groups	1090.01	261	4.18		
	Total	1091.04	262			

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
first person pronouns	Between groups	946.39	1	946.39	6.81	ns
	Within groups	36257.83	261	138.92		
	Total	37204.22	262			
second person pronouns	Between groups	0.34	1	0.34	8.21	ns
	Within groups	10.79	261	0.04		
	Total	11.13	262			
third person pronouns	Between groups	115.32	1	115.32	27.06	<.0001
	Within groups	1112.06	261	4.26		
	Total	1227.37	262			
activity verbs	Between groups	1620.12	1	1620.12	49.13	<.0001
	Within groups	8606.26	261	32.97		
	Total	10226.38	262			
mental verbs	Between groups	1047.02	1	1047.02	87.61	<.0001
	Within groups	3119.04	261	11.95		
	Total	4166.06	262			
causative verbs	Between groups	84.29	1	84.29	21.4	<.0001
	Within groups	1027.77	261	3.94		
	Total	1112.06	262			
communication verbs	Between groups	11.89	1	11.89	4.83	ns
	Within groups	642.75	261	2.46		
	Total	654.64	262			
occurrence verbs	Between groups	42.07	1	42.07	23.99	<.0001
	Within groups	457.75	261	1.75		
	Total	499.82	262			
aspectual verbs	Between groups	146.96	1	146.96	63.63	<.0001
	Within groups	602.81	261	2.31		
	Total	749.78	262			
agentless passives	Between groups	87.30	1	87.30	2.49	ns
	Within groups	9163.83	261	35.11		
	Total	9251.13	262			
by-passives	Between groups	3.09	1	3.09	2.41	ns
	Within groups	335.33	261	1.28		
	Total	338.42	262			
all modals	Between groups	4202.78	1	4202.78	111.9	<.0001
	Within groups	9805.49	261	37.57		
	Total	14008.27	262			
possibility modals	Between groups	36.67	1	36.67	8.08	ns
	Within groups	1184.49	261	4.54		
	Total	1221.16	262			
necessity modals	Between groups	127.54	1	127.54	58.24	<.0001
	Within groups	571.54	261	2.19		
	Total	699.08	262			

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
prediction modals	Between groups	2259.37	1	2259.37	105.3	<.0001
	Within groups	5600.78	261	21.46		
	Total	7860.15	262			
type/token ratio	Between groups	38.95	1	38.95	4.27	ns
	Within groups	2380.20	261	9.12		
	Total	2419.15	262			
average word length	Between groups	0.66	1	0.66	4.32	ns
	Within groups	39.62	261	0.15		
	Total	40.28	262			
nominalizations	Between groups	1886.91	1	1886.91	8.67	ns
	Within groups	56809.49	261	217.66		
	Total	58696.40	262			
prepositions	Between groups	8570.51	1	8570.51	46.89	<.0001
	Within groups	47700.54	261	182.76		
	Total	56271.05	262			
subordinating conjunctions (causative)	Between groups	11.40	1	11.40	11.39	0.0009
	Within groups	261.40	261	1.00		
	Total	272.80	262			
subordinating conjunctions (condition)	Between groups	27.91	1	27.91	23.93	<.0001
	Within groups	304.35	261	1.17		
	Total	332.26	262			
subordinating conjunctions (other)	Between groups	11.19	1	11.19	4.77	ns
	Within groups	612.38	261	2.35		
	Total	623.57	262			
coordinating conjunctions (clausal)	Between groups	0.39	1	0.39	0.05	ns
	Within groups	2009.26	261	7.70		
	Total	2009.64	262			
coordinating conjunctions (phrasal)	Between groups	0.00	1	0.00	0	ns
	Within groups	315.14	261	1.21		
	Total	315.14	262			
THAT clauses	Between groups	48.40	1	48.40	10.61	0.001
	Within groups	1190.67	261	4.56		
	Total	1239.07	262			
TO clauses	Between groups	683.99	1	683.99	101.9	<.0001
	Within groups	1752.25	261	6.71		
	Total	2436.24	262			
WH clauses	Between groups	1.41	1	1.41	8.19	ns
	Within groups	44.96	261	0.17		
	Total	46.37	262			

Table J2. ANOVA Results for Comparisons across Ten Organizational Units (i.e., Abstract, Executive Summary, Introduction, Methods, Results, Methods and Results, Discussion, Results and Discussion, Conclusion, and Recommendations) of Professional EDRs ($\alpha = 0.001$)

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
nouns	Between groups	78380.36	9	8708.93	5.25	<.0001
	Within groups	563751.24	340	1658.09		
	Total	642131.60	349			
verbs	Between groups	5195.08	9	577.23	1.83	ns
	Within groups	107217.11	340	315.34		
	Total	112412.18	349			
adjectives	Between groups	31013.64	9	3445.96	6.98	<.0001
	Within groups	167932.05	340	493.92		
	Total	198945.70	349			
adverbs	Between groups	2798.84	9	310.98	2.32	ns
	Within groups	45606.23	340	134.14		
	Total	48405.07	349			
nominalizations	Between groups	22306.82	9	2478.54	4.29	<.0001
	Within groups	196347.89	340	577.49		
	Total	218654.71	349			
group nouns	Between groups	76.34	9	8.48	1.1	ns
	Within groups	2616.95	340	7.70		
	Total	2693.29	349			
cognition nouns	Between groups	108.59	9	12.07	0.52	ns
	Within groups	7896.92	340	23.23		
	Total	8005.51	349			
animate nouns	Between groups	185.81	9	20.65	2.17	ns
	Within groups	3237.79	340	9.52		
	Total	3423.60	349			
technical nouns	Between groups	648.35	9	72.04	0.81	ns
	Within groups	30179.89	340	88.76		
	Total	30828.23	349			
quantity nouns	Between groups	2452.75	9	272.53	2.51	ns
	Within groups	36981.43	340	108.77		
	Total	39434.18	349			
concrete nouns	Between groups	1018.79	9	113.20	0.48	ns
	Within groups	79465.11	340	233.72		
	Total	80483.90	349			
abstract nouns	Between groups	2566.19	9	285.13	0.79	ns
	Within groups	123257.47	340	362.52		
	Total	125823.66	349			
process nouns	Between groups	8399.75	9	933.31	4.75	<.0001
	Within groups	66782.32	340	196.42		
	Total	75182.07	349			

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
place nouns	Between groups	255.95	9	28.44	0.78	ns
	Within groups	12354.67	340	36.34		
	Total	12610.62	349			
first person pronouns	Between groups	530.46	9	58.94	1.25	ns
	Within groups	16004.77	340	47.07		
	Total	16535.23	349			
second person pronouns	Between groups	0.02	9	0.00	1.6	ns
	Within groups	0.55	340	0.00		
	Total	0.58	349			
third person pronouns	Between groups	102.95	9	11.44	1.1	ns
	Within groups	3540.53	340	10.41		
	Total	3643.47	349			
aspectual verbs	Between groups	149.71	9	16.63	1.08	ns
	Within groups	5227.46	340	15.37		
	Total	5377.16	349			
occurrence verbs	Between groups	669.87	9	74.43	4.16	<.0001
	Within groups	6077.75	340	17.88		
	Total	6747.63	349			
communication verbs	Between groups	620.29	9	68.92	2.31	ns
	Within groups	10155.50	340	29.87		
	Total	10775.79	349			
causative verbs	Between groups	273.34	9	30.37	1.4	ns
	Within groups	7357.26	340	21.64		
	Total	7630.60	349			
mental verbs	Between groups	372.87	9	41.43	1.15	ns
	Within groups	12283.61	340	36.13		
	Total	12656.47	349			
activity verbs	Between groups	746.26	9	82.92	0.88	ns
	Within groups	32042.82	340	94.24		
	Total	32789.08	349			
agentless passives	Between groups	2052.91	9	228.10	1.84	ns
	Within groups	42090.69	340	123.80		
	Total	44143.60	349			
by-passives	Between groups	74.09	9	8.23	1.08	ns
	Within groups	2579.65	340	7.59		
	Total	2653.74	349			
present tense	Between groups	6132.88	9	681.43	2.02	ns
	Within groups	114971.65	340	338.15		
	Total	121104.53	349			
past tense	Between groups	6313.68	9	701.52	3.09	0.001
	Within groups	77136.61	340	226.87		
	Total	83450.28	349			

Variable	Source of variance	Sum of Squares	df	Mean Square	F	Sig
perfect aspect verbs	Between groups	792.46	9	88.05	2.21	ns
	Within groups	13575.67	340	39.93		
	Total	14368.13	349			
progressive verbs	Between groups	283.96	9	31.55	1.42	ns
	Within groups	7530.15	340	22.15		
	Total	7814.11	349			
possibility modals	Between groups	353.12	9	39.24	1.63	ns
	Within groups	8164.15	340	24.01		
	Total	8517.27	349			
necessity modals	Between groups	194.31	9	21.59	4.62	<.0001
	Within groups	1588.00	340	4.67		
	Total	1782.30	349			
prediction modals	Between groups	631.70	9	70.19	1.76	ns
	Within groups	13521.33	340	39.77		
	Total	14153.02	349			

APPENDIX K. CODING SCHEME FOR GENRE ANALYSIS OF PROFESSIONAL ENGINEERING DESIGN REPORTS

Assumptions

The Assumptions move is used to discuss various assumptions related to the design project or to the various applications of the design artifact. It typically includes explicit statements about assumptions and may include numbered or bulleted lists.

1. Conveniently, designing a community-scale water treatment system, as opposed to household scale treatment units, allows us to consider the use of a wider array of technologies in the arsenic removal process. We assume that a trained technician instead of an untrained user would maintain the treatment system. We also assume access to electricity or, because of the size of the system, that it would be appropriate and affordable to incorporate a power source into the system design. Note that ARUBA treatment does not require electricity; however, hand-pumping enough water for an entire community would be impractical and would violate strategy 2. (Pr1_09_3)
2. To calculate tandem efficiency, we assumed the following:
    1) The Voc for the a-Si top cell was 0.88V, which rather conservative since we have already obtained Voc=0.92V but it might decrease with lower bandgaps. Voc was independent of Jsc or thickness, which is consistent with experimental results in this range.
    2) The FF for the top cell was 68% independent of bandgap. This is conservative.
    3) The Voc for the Si bottom cell decreased as ln(Jsc) as predicted by the standard equation. This represented a 20-40 mV loss over the range of top cell Jsc considered here.
    4) The FF for bottom Si cell was 76% independent of its Jsc or Voc. (Pr4_08_2)

Background

The Background move typically provides pertinent information about the move that immediately follows it. For instance, the Introduction unit's Background move introduces the area of research and development efforts, establishes importance of this area or of specific design work, and provides background information necessary for understanding of the design project. Further, in the Methods unit, this move provides pertinent information about specific procedures used in the course of the project.

1. There are a variety of new research avenues in thermophysical science and engineering technology development that require optical access to high-temperature and high-pressure environments. Applications of these techniques are contributing to materials synthesis research, pressurized water reactor studies, and supercritical fluids research. (Pr1_00_4)
2. Silicon carbide (SiC) is widely known for its potential as a structural material for MEMS devices designed to operate in harsh environments (i.e., high temperature, radiation, wear, etc.). It has robust mechanical properties that make SiC very attractive for RF MEMS applications. When used as the structural material in

micromachined bridges, the inherent stiffness and tensile stresses of SiC results in beams that are extremely resistant to sagging. Moreover, its chemical inertness makes SiC highly resistant to stiction. These properties make SiC an ideal alternative to metals in surface micromachined bridge-based RF MEMS switches for the reasons described above. Incorporation of insulating, amorphous SiC as the main mechanical structure in bridge-based RF switches eliminates the need to use a stiction-preventing insulating film between the cantilever and transmission because the SiC itself is highly resistant to stiction, due to its chemical inertness coupled with its resistance to oxidation. (Pr3_08_4)

Current Design

The Current Design move presents solution(s) for problem(s) identified in the Need for Project move, by describing the main features of an artifact that is being designed.

1. The S4 system addresses these challenges with a new storage management structure. The storage management system uses a log-structured object system for data versions, a novel journal-based structure for metadata versions, and an opportunistic on-disk anti-entropy cache for restoring sequentiality to version-scrambled objects. (Pr2_00_1)
2. The current paper discusses the development of a new test fixture to assess advanced seal concepts in simulated reentry heating conditions. This test fixture will permit testing of a variety of seal sizes, shapes, and materials against a wide range of candidate advanced control surface designs and materials at near-operating temperatures and pressure drops. (Pr3_04_3)

Description of Materials: Functional

The Functional Description of Materials (DOM Functional) move provides functional descriptions of the design components. That is, this move describes how design components work.

1. The anti-entropy cache keeps a sequential copy of an object's direct blocks (up to 60KB) along with the object's onode and ACL table in a special segment. When a read request is made, the entire anti-entropy cache can be read, retrieving the object's metadata along with the stored data in one, quick operation. Because of their limited size, they currently have little effect on large files, but smaller, rapidly changing files can have improved read performance over other log-structured file systems. (Pr2_00_01)
2. The pump uses a direct shaft to the motor rotor, so no in-line magnetic coupling is used to maintain fluid sealing. A stationary fluid barrier encases the entire pump cartridge and rotor shaft, segregating the working fluid from the stator and Hall Effect sensors. The stationary fluid barrier terminates at the motor end of the assembly using an o-ring seal between the OD of the barrier and the ID of motor housing bore (bore seal). This approach provides semi-hermetic sealing of the working fluid. Magnetic coupling links the stator to the rotor; as in a typical motor, only the magnetic flux passes through the thin metallic fluid barrier. (Pr3_10_2)

Description of Materials: Physical
The Physical Description of Materials (DOM Physical) move describes any items or components used in the design project. DOM Physical move typically describes how a particular component looks like or what it consists of.

1. The sub is a tubular tool, 7" in diameter by approximately 85" long, with a central electronics/sensor package suspended by three-legged supports inside the structural housing (see Figure 1). The metal parts of the tool are made from non-magnetic materials to allow proper magnetometer operation, and the structural case is sized for the loads typical in drilling 8-1 /2" hole. (Pr1_03_1)
2. Currently, the main processor used in the NERD is the ipEngine made by BrightStar Engineering. The ipEngine is based on Motorola's PowerPC MPC823 processor. It offers a 50MHz processor, 16MB DRAM, 4MB Flash memory, 10Base-T Ethernet, 16W power output, 16,000 gate FPGA, 132 pin virtual I/O interface, USB host/slave controller, LCD/Video controller and dual RS-232 ports. The ipEngine draws a maximum of 250mA at 12VDC. (Pr2_02_3)

Evaluation
The Evaluation move provides the authors' assessment of the design project, which typically involves the discussion of the effectiveness of the artifact and/or the comments about the overall success of the design project. As such, this move often entails comparisons of the project outcomes to its objectives.

1. The Proof-of-Concept testing validated the successful function and utility of the DWD system. All drilling objectives were met and performance of the interconnected DWD hardware and software elements was, especially for a complex new system with no history of drilling in an actual hole, outstanding. (Pr1_03_1)
2. As a result of this program, over 80 new PV arrays, utilizing developments from this program, have been installed on rooftops in the greater Sacramento metropolitan area. The Power Unit and Energy Storage Unit (ESU) have been built and tested, and have met the technical goals set forth. The feasibility of such a system has been demonstrated. … The goal for the Power Unit, operating at the higher voltage from the Energy Storage Unit, was to achieve a conversion efficiency of greater than 94% at 100% of rated output power, with total harmonic distortion below 5%. The Power Unit prototype has exceeded this goal by achieving measured performance of 96% efficiency and total harmonic distortion under 2%, at power levels of 30% to 100% of rated output power. (Pr1_02_2)

Follow-Up Activities
In the Follow-Up Activities move, professional EDR writers identify work that needs to be done in the future. This can be work planned for another design project or activities that were not yet accomplished in the course of the same project.

1. We expect to complete our current suite of tests involving the use of static gas in the prototype units by Q3 of FY05 and should be able to finalize the endstation design by the end of the FY. The high-pressure gas handling system needed to run performance tests with the cross-flow venturi in place will be designed in late

FY05 and should be ready for use sometime in FY06. (Pr1_05_2)

2. A similar approach is planned for the firmware implementation. We intend to add features and functionality incrementally, and slowly move on chip many of the functions and operations that we will be performing at first on the local computer. (Pr1_05_3)
3. Work is also underway to provide the necessary altitude simulation capabilities for ramjet direct-connect and free-jet testing modes. Altitude simulation capabilities are pertinent to evaluate ramjet performance during conditions when combustion chamber pressures are low. (Pr2_02_4)

Implications

The Implications move involves discussions about benefits from using the artifact, decrease in existing negative factors, commercialization potential of the artifact, and various ways of its implementation.

1. Multiport dryer technology will provide the following attractive benefits and impacts:
   - Increased drying rate or increased productivity, a major impact of the multiport cylinder dryer technology on the paper production industry, comes from the potential to increase paper drying rates or production rates in existing machines. An increase in drying rate can be viewed in two ways. The number of dryers can be reduced while paper production rate remains the same, or alternatively, system speed can be increased to produce paper at a higher rate with the same number of dryers. In the latter case, current experimental data show that multiport cylinder dryers can potentially increase paper drying or production rates by as much as 20% when compared with spoiler bar technology, and by as much as 90% when compared with existing technology without spoiler bars (see Fig. 14).
   - … (Pr1_01_1)
2. The knowledge gained from our studies will broadly impact the AFOSR. Recent events in this Nation highlight the need for the detection and quantification of biological and chemical reagents for each person in the civilian and military population. Our work provides the underpinning to develop technologies that address this need (e.g. "wristwatch" sensors). We expect to obtain microsensors possessing unprecedented performance capabilities. We see the transfer of the tools developed in this program to other AFOSR fields as an important benefit of the proposed work. Two examples come to the fore. The methods developed in this program will allow for the invention of new optical diagnostic tools for mapping chemical and physical processes in micro- and nano-domains especially in small channels and near surfaces. … (Pr2_05_3)

Lessons Learned

In the Lessons Learned move, professional EDR writers discuss particular outcomes of the project that have consequences for similar projects in the future. Rather than provide recommendations for these projects, the Lessons Learned move is used to simply reflect on the authors' own experiences and results.

1. We find that by packaging the sensors in a conducting enclosure reduces the noise a great deal. A single dust particle source is needed to test the velocity/charge sensor. (Pr3_03_1)
2. However the electrostatic adhesions of dust particles require an extra effort to clean the detector. The PZT can be made very small. It has a fast response, simple design, and is very inexpensive. The PZT needs calibration for temperature and momentum/voltage sensitivity. We selected the PZT over the QCM for the reasons that PZT handles the dust adhesion with better single response for single dust particle, and smaller physical size. The PZT sensor is capable of measuring the individual particle mass to collect the mass distribution of Martian dust particles and total charges over a given period of time. (Pr3_03_1)

Need for Project
The Need for Project move's function is to establish the purpose for the design project. Thus, this move typically identifies the project's objective(s) and/or problems(s) to be solved. It may discuss limitations of the currently used designs, thus setting up a stage for the current project. The move can be realized by simply stating the project's objective(s) and/or indicating interest of the project's sponsoring agency.

1. It is common practice to use lasers for precision aiming of shaped charge jets. The laser aimers currently deployed suffer from two operational deficiencies: 1) The beam from the red diode lasers used in these aimers is difficult to see in some conditions, particularly in sunlight, and 2) They are attached to the shaped charge directly in line with the jet axis so they must be removed prior to firing the charge. Removal of the laser from the charge creates the possibility of accidental movement of the charge and precludes the possibility of verifying charge alignment immediately prior to firing the charge. (Pr1_07_3)
2. The objectives of this grant are to simulate and fabricate an optimized micromachined microjet array (MJA) impingement cooling device for high power electronics. A chip-scale microjet impingement cooling device will also be implemented with heat source fabricated on its target plate. (Pr2_04_4)

Overview of the Report
The Overview of the Report move is used to orient the reader about the structure of the entire design report. If included in the report, this move can be typically found at the end of the EDR Introduction unit.

1. This report discusses the efforts associated with the development of a DWD system capable of sustained operation at 225 °C. (Pr1_09_1)
2. This paper describes self-securing storage and our implementation of a self-securing storage system, called S4. (Pr2_00_1)

Optimization and Troubleshooting
The Optimization and Troubleshooting move describes attempts to either (a) solve a problem encountered during design and/or testing procedures or (b) optimize a specific outcome of these procedures or of the project overall.

1. The cylinder head was removed and upon further inspection a crack was discovered at the edge of the valve seat. There were no engine or vehicle inspections performed on the test vehicles prior to the project. Therefore, it is difficult to assess when the crack occurred. This event was considered an anomaly and the cylinder head was replaced. The compression test was repeated with the new head and the difference between the maximum and minimum cylinder readings was 1.5%. (Pr4_05_1)
2. Although the "rabbit-ear" cables and this method of bonding the center of the cable were used on all of the CX3 motors shipped to Sandia, this method was crude and the adhesive was difficult to apply. A better cable design was desired. To evaluate the problems in the "rabbit-ear" cable design and guide the design of a new cable to eliminate these problems, a series of finite element analyses was performed. (Pr1_00_2)

Planning and Project Management

In the Planning and Project Management move, professional EDR writers propose a plan for the design activities. This move can typically be found in the Introduction unit and includes verbs in the future tense describing design activities.

1. Three ways to control the matching and obtain higher tandem currents that will be investigated include increasing the top cell thickness, decreasing its bandgap, or increasing its effective absorption using optical enhancement. (Pr4_02_8)
2. In the proposed research, intrinsic rate expressions will be determined based on the inlet concentrations (reactant, water vapor and oxidizer such as ozone, if present) and will include closed form light flux dependency. A transport model (which takes into account the flow patterns and the mass transfer effects) will be developed. Based on the reactor geometry and the conditions, the transport model will consist of a system of coupled partial differential equations (PDE) with non-homogeneous boundary conditions. (Pr2_00_3)

Potential Problems

Potential Problems move presents problems that the EDR writers considered but which did not occur in the course of the design project. These potential problems are reported because they can be encountered by other professionals attempting similar projects.

1. The combination of restrictions on Inside Diameter to 4.25 inches and Outside Diameter held to 5.81 inches, coupled with load/temperature/fatigue requirements derived from an existing steel pipe, presents a strenuous engineering task. It is possible that all Design Load Conditions and Combinations, as currently presented in the tube of the CDP, Table 1, may not be met Simultaneously. (Pr1_00_1)
2. A potential issue with such a trivial data accessing is the relatively strong overlapping of the field profiles used for recording into adjacent bit cells. To illustrate this issue, Figures l0a and b show the magnetization pattern (a) right after some information is recorded into both layers of a two-layer dc-saturated medium and (b) when one of the adjacent cells has been preliminarily

recorded, respectively. The highlighted overlapped region indicates the region in the medium where the information is "wasted". (Pr2_04_1)

Previous Work

The Previous Work move describes previous efforts to solve specific problem(s) discussed in the Need for Project move. The move only discusses work that is deemed relevant for the project and in doing so typically refers to specific organizations and people and, thus, includes names, references, places, and dates. Previous Work move is also used to further provide necessary information about the current design project, sometimes discussing its historical development, specifically providing account to its major participants.

1. This approach was originally tested in 1997 at an EPA test incinerator, where the filters were analyzed offline (French 1998). Cooper Environmental Services (CES) further developed this method into an online system tested under the ERDC/CERL Waste Minimization and Pollution Prevention Program at MSE Technology Applications, Inc.'s (MSE-TA's) research incinerator in Butte, MT (Bryson et al. 2000). The results were encouraging because the XCEM met the PS-10 RA requirements for chromium (Cr) and lead (Pb). Many of the other requirements were unmet, however, and further development was needed. It was at this point that ERDC/CERL began funding the development of XCEM technology under their Hazardous Air Pollutants (HAP) program. Table 1 lists the Army's 19 existing, new, or planned hazardous waste combustors (Josephson 2003). (Pr5_05_1)
2. NASA Langley Research Center has taken a leading role in developing instrumentation to pursue these longer wavelength measurements. A stepping stone has been the development of the Far-Infrared Spectroscopy of the Troposphere (FIRST) instrument for balloon-borne measurements to 100 μm in the far-infrared. (Pr3_07_1)

Problems Encountered

In the Problems Encountered move, professional EDR writers acknowledge and frequently explain the unexpected outcome(s) of the design or testing procedures.

1. The largest unexpected challenge encountered was friction in the elbow joint and between the muscle and the arm. (See Figure 11.) Ideally, the whole system would have no static friction, and its viscous friction would come only from viscoelastic behavior in the muscles. (Pr1_04_1)
2. A post-HOST spin test of the NCC turbo machines resulted in a failure to start the circulator. Investigation revealed contact between the shaft and bearings with substantial damage to the anodized titanium surfaces most likely caused by moisture contamination present in the loop. (Pr3_02_2)

Procedures
The Procedures move, describes procedures and instrumentation used in the design project. The procedures described could be design procedures (e.g., steps taken to create an artifact) or analytical procedures (e.g., decision-making procedures that involve alternative design considerations).

1. Once the base layers of imagery were established, subsurface features such as faults, geologic strata variances as documented at the time of construction, dam-foundation features, etc., were added to form the third dimension (subsurface). Existing paper cross sections were digitized and rectified, such that their relationships to each other could be established. (Pr5_07_1)
2. To meet the engine requirements, the Pulse system by B&K was selected as the hardware platform. The Production Test Advisor (PTA) by Signalysis, Inc. was selected as the database management system. MATLAB (The MathWorks, Inc.) based post-processing system was developed in-house at GE and integrated into the system for real-time health monitoring. A brief system diagram is shown in figure 3. (Pr3_06_3)

Project Summary
The Project Summary move reports on activities that were carried out in the course of the design project and culminated in the creation of the artifact.

1. A blade structural design code was developed in support of a project comparing two- and three-blade rotors for a hypothetical turbine. The code generated blade designs and their structural properties. Based on these properties, we built aeroelastic models of two- and three-blade rotors for comparative studies. The theory basis for the blade design code, which uses the classical laminate theory, has already been reported [1]. (Pr4_04_1)
2. The XCEM was developed under this project through contracts with CES (DACA42-00-P-0245 and DACA42-01-R-008). A prototype was constructed incorporating necessary improvements determined from the Butte testing, such as user friendliness, automation, and the capability to monitor mercury (Hg). This prototype was then tested in the laboratory by comparing it against the EPA Reference Method 29 (M29). A new monitor was constructed and readied for demonstration at the 1236 production deactivation furnace at Tooele Army Depot (TEAD), UT. (Pr5_05_1)

Recommendations
In this move, professional EDR writers provide suggestions for future improvements of the design, its procedures, and/or components.

1. Thus a design objective of a 300ºC tool should be to eliminate this “hinge” effect. As noted above, this requires that the problem of space to contain the strain gauges be addressed, as well as the trade off between strain in the steel to which the strain gauges are mounted and resolution of the measurements. (Pr1_09_1)
2. In the future, the eXisting model or larger 3-D models should be modified to include blown tail surfaces and additional improvements to the pneumatic thrust

deflection system. The following should be experimentally investigated. (Pr3_04_1)

Requirements and Constraints

The Requirements and Constraints move details requirements and/or constraints for the design. This move is most frequent in the Methods and Introduction units and typically includes numbered or bulleted lists.

1. The mandatory conditions for a successful v-band design are:
   The spreader force Fs may not exceed 33.4 kN (7500 Ibr), to avoid failure of the spreader mechanism (external to the v-band itself) .
   - The v-band material itself (AISI 4340 Q&T fully hard) must not fail due to Ft
   - The ramp angle of the v-band must be large enough to ensure it is not self-locking with the mating surfaces on the two cylinders when the axial load is applied. (Pr1_02_1)
2. Sandia National Laboratories convened two workshops aimed at defining a research goal, and concluded that the target technology would be incorporated into an advanced geothermal drilling system that met the following criteria:
   1) The system would perform all the necessary functions for drilling a model geothermal well.
   2) The system would reduce the cost or economic risk of drilling a geothermal well and/or improve the lifetime productivity of the well , thereby reducing well cost/unit heat.
   3) The system would contain one or more key components that do not currently exist, but which might be developed with DOE funding. (Pr1_03_1)

Results

The Results move is used to both report and interpret the outcomes of the design project and its procedures.

1. Test results are an average of three replicate tests and are shown in Tables 8 and 9 for the CSHVR and OCTA test schedules respectively. The same emission measurements are presented graphically in Figures 9 through 12. These figures also show the maximum and minimum emission values and indicate excellent repeatability for NOx and hydrocarbons. Repeatability for PM and CO is not as good because of the extremely low values measured (Pr4_05_1)
2. XCEM and M29 concentrations for the four M29 test runs are shown in Table 6. Reported concentrations for the two methods are in good agreement for all elements except Ag. No apparent overall bias is evident between the two methods. Indeed, the overall average non-Ag metal concentrations reported by the two methods are within a few percent of each other. This trend holds true for each sample run (Table 7) and indicates that it is probable that no particulate loss occurred in the sampling system. (Pr5_05_1)

Section Blurb

The Section Blurb move generally introduces the whole unit and most frequently opens it. If the unit contains sections, each of them may be preceded by the Section Blurb move.

1. System Architecture-The system architecture is the build up of materials in the flexible system. This section explains in detail how all these materials fit together and dimensions of certain components. (Pr2_04_4)
2. The following sections describe how the design goals were met for this test fixture. (Pr3_04_3)

Summary

The Summary move frequently contains a brief recap of the project's most important accomplishments, frequently including the main features of the designed artifact. Because the Summary move often reduces pages of information presented in various EDR units, it regularly features numbered and bulleted lists.

1. Key technical conclusions include:
    - Spectral control performance is important for TPV cell performance in a TPV system and influences the optimum bandgap for a given radiator temperature.
    - Low bandgap TPV cells are conceptually enabling for both higher TPV efficiency and higher power density when spectral control limitations are included.
    - Front surface tandem filters have achieved the highest spectral control performance for TPV energy conversion.
    - Higher performance for front surface, frequency selective surface (FSS) filters is limited due to finite conductivity of the metal used to create the surface. Therefore, FSS filters do not satisfy the strict requirements for high spectral efficiency and high above band gap transmission as compared to current tandem filter technology.
    - Back surface reflectors have achieved useful levels of spectral performance but less than the spectral performance of tandem filters. Higher performance for back surface reflectors is limited by free carrier absorption in the TPV cell layers.
    - The spectral performance of radiator materials for TPV spectral control lags the performance of front surface, tandem filters for energy conversion in an application requiring maximum power density. (Pr1_07_4)
2. Based on the research conducted in this study the following conclusions can be presented:
    1) Design of a new type of face gear drives that could be applied in aircraft have been developed. Such gear drives provide: (i) application of new types of planetary gear drives with coaxial axes of input and output shafts, (ii) face gear drives with split torque, (iii) new design of a planetary face gear drive.
    2) New geometry of face gear drives based on application of parabolic rack-cutters.
    3) Generation of face-gears by a worm of a special shape.
    4) Efficiency comparison of the various gear train arrangements was performed

and generally the efficiency was lower for higher gear reduction ratios. (Pr3_04_4)

Testing Equipment
Testing Equipment move describes specific equipment that was used in the testing procedures. Typically this equipment deserves to be detailed because it is not common. The move is relatively common in the M&R, Results, and R&D units.

1. The apparatus was designed and fabricated to study condensing heat transfer of steam at pressures up to 1035 kPa (150 psi) and temperatures up to 180°C (356°F) in a small rectangular channel. Figure 4 shows a digital picture of the MD heat transfer test apparatus. The channel cross-sectional area, pressure, and temperature are typical for a multiport cylinder dryer. The facility includes four flow loops, as described below, and shown schematically in Fig. 5. The test section, which is itself a heat exchanger, is between the water/steam loop and the water/coolant loop. (Pr1_01_1)
2. The apparatus, shown schematically in Figure 1, consisted of an externally illuminated flow tube photoreactor, a flow control section, and a gas analysis section. The photoreactor is a 48” section of 2.24” ID quartz tube. The photocatalyst titania (Degussa P25) was wash coated on the inside surface of this cylindrical tube. Photoillumination was provided by a bank of six 40W ultraviolet black lamps (General Electric) that were held around the reactor tube. These lamps have a broadband emission spectrum, which peaks at 365 nm. The lamp assembly was enclosed inside an aluminum box. (Pr2_00_3)

Testing Procedures
The Testing Procedures move critically evaluates the components of the design or the complete design according to specific predetermined requirements.

1. For the rectangular and rhombus sections, both methods produced virtually identical results. For the circular and elliptical sections, the results were very close. The slight discrepancies, due to the piecewise straight-line discretization of circular and elliptical peripheries, became negligibly small as we refined the discretization. We also used an actual 6-meter-long blade to validate the analysis option of the code. The error between the computed and the actual properties was less than 2%. (Pr4_04_1)
2. The results of this analysis show that elastic joint strength increases with joint length, ranging from 13,341 lb./inch-width to a maximum of 16,313 lb./inch-width. (Pr1_01_1)