

Multidimensional Linguistic Analysis of Multiple Undergraduate Writing Samples Collected from Engineering Students in Entry-level Laboratory Courses at Three Universities

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Abstract:

This study aims to identify the linguistic feature characteristics of multiple writing assignments completed by engineering undergraduates, including entry-level engineering laboratory reports and writing produced in non-engineering courses. We used Biber's multidimensional analysis (MDA) method as the analysis tool for the student writing artifacts. MDA is a corpus-analysis methodology that utilizes language processing software to analyze text by parts of speech (e.g., nouns, verbs, prepositions, etc.). MDA typically identifies six "dimensions" of linguistic features that a text may perform in, and each dimension is rated along a continuum. The dimensions used in this study include Dimension 1: Informational vs. involved, Dimension 3: Context dependence, Dimension 4: Overt persuasion, and Dimension 5: Abstract vs. non-abstract information. In the academic year (AY) 2019-2020, total of 97 student artifacts ($N = 97$) were collected. For this analysis, we grouped documents into similar assignment genres: research-papers ($n = 28$), technical reports and analyses ($n = 5$), and engineering laboratory reports ($n = 35$), with individual engineering students represented at least once in the laboratory report and once in another category. Findings showed that engineering lab reports are highly informational, minimally-persuasive, and featured more immediate elaboration on claims and data. Conversely, students' research papers in academic writing courses were highly involved, highly persuasive, and used deferred elaboration. The analyses above indicate that students are generally performing as expected in lab report writing in entry-level engineering lab classes, and that this performance is markedly different from their earlier first-year-composition, indicating that students are not already "writing like engineers" in their first year at college. However, similarities in context independence and non-abstract dimensions suggest that engineering students must still learn to modulate their languages in writing depending on the writing assignment. The MDA results also indicate that the technical report's student performance mean and range were placed between argumentative research paper and lab report. As a result, writing experiences of technical reports can be expected to enhance engineering students' ability to change their register or other linguistic/structural features to meet the expectations of the range of audiences.

1. Introduction

Lower-division engineering students in four-year colleges are exposed to many writing assignments not only from their STEM courses but also from general education courses. Often, they are assigned to write argumentative papers on humanities subjects; at the same time, they need to write lab reports for engineering labs. This means that the audience expectations of writing assignments vary for lower-division engineering students. Indeed, the Accreditation Board for Engineering and Technology, Inc. (ABET) specified it as Student Outcome 3, "an

ability to communicate effectively with a range of audiences”; therefore, offering education related to effective communication with a range of audiences is essential in engineering programs. However, we do not have enough knowledge about how engineering students perform their writing practices during lower-division education.

In engineering education, multiple efforts have been made to analyze or characterize engineering students’ writing. Conrad and her team published multiple articles [1, 2, 3, 4] to investigate the characteristics of effective writing in civil engineering practice. They analyzed the organization, sentence structure, and grammatical errors of the technical memos written by students in civil engineering classes and compared them to the same genre written by civil engineering practitioners. When compared with civil engineering practitioners’ technical memos, students’ memos had a less predictable and linear organization, a complicated sentence structure with more embedding, and multiple grammatical errors. In short, students did not achieve the level of accuracy and precision that the engineering practitioners demonstrated in technical memo writing. Conrad’s team [4] expanded the scope of the work to approximately 400 student papers and 400 practitioner documents from 50 firms and agencies, including ten genres (e.g. technical memoranda, reports, proposals, e-mail messages) to analyze the organization, grammar choices, and grammar and punctuation errors. They strengthened the knowledge learned from their previous work [3] that a lack of accuracy and precision might come from the students’ word choice being superlatives and absolutes (e.g. “the *best* design to *ensure*”) as well as vague words (e.g. “at *really high* temperature”). They also documented other weakness in student writing, when compared with engineering practitioners’, as “a greater use of passive voice; a lack of awareness of connections between ambiguous writing and unintentional liability; choppy content development due to the writers’ failure to follow typical information flow in English; and a much higher rate of grammar and punctuation errors” [3].

While Conrad’s team used linguistics as a theoretical framework to characterize engineering students’ written reports, Kelly et al. [5] have applied linguistics to analyze engineering students’ oral and written communication in an introductory engineering course. They used systemic functional linguistics (SFL), as described by Halliday and Matthiessen [6], to examine the relationship between fundamental language use (stratification) and its context (actualization) of students’ oral presentations and writing samples. Kelly et al. [5] identified the communication’s general purpose and the student’s field as the subject matter context, decomposed by quality of information and the use and organization of technical terms. They also used the complexity of the field as the instrument to assess students’ communications in one class for a semester long. They concluded that the SFL approach could quantify students’ engineering academic language use. Findings included that the use of the register, or actual technical terminology, increased slightly over the semester. However, the complexity of field was a difficult area of achievement by students through the semester in the introductory engineering course.

With funding from the National Science Foundation, we aim to characterize the register of engineering student writing in lower-division engineering courses by using Biber’s multidimensional analysis (MDA) method. MDA offers a quantitative description of the grammatical and organizational structure of each document, and as a corpus linguistics tool, it can easily be performed on large collections of text. For the analysis, we grouped documents into similar assignment genres: first-year-composition research-papers, technical reports and

analyses, and engineering laboratory reports, with individual engineering students represented at least once in the laboratory report and once in another category. The primary piece of information we discuss here will be whether or not student work *approximates* the type of document they are asked to produce in an assignment: first-year composition essays should have the features of Academic Prose (not like professional engineering writing), technical communication documents should have the features of Learned Reporting (perhaps sharing engineering traits, but not looking like Academic Prose) and lab reports should also have the features of Learned Reporting.

This paper will present the MDA analysis results from three assignment genres to discuss how lower-division engineering students in three 4-year schools change their linguistic features for the range of audiences in academic writing.

2. Methods of approach

2.1 Analysis process overview

2.1.1 Recruitment and Study Area

This study took place across three universities in the Pacific Northwest: Oregon Institute of Technology (OIT) - a public polytechnic university, the University of Portland (UP) - a private university, Washington State University (WSU) Vancouver - one campus of WSU, a multi-campus land-grant university. In AY 2019-2020, approximately 300 engineering students in introductory-level laboratory courses across all universities were invited to participate in the study. To participate, students completed an IRB-approved consent form which required them to submit either first-year composition (or equivalent) or their technical writing assignments in addition to engineering lab reports. Writing from adjacent fields (e.g. an introductory philosophy course that, in practice, serves as first-year composition at the private university) was accepted as well.

2.1.2 Sample Size

Of the students invited to participate, 33 students submitted 142 artifacts. From this cohort, 97 artifacts could be meaningfully analyzed using MDA. This final set includes 23 students with artifacts in both a writing class and an engineering class (providing longitudinal data). The final set of students includes 10 students in Electrical Engineering, 8 students in Computer Engineering, 8 in Mechanical Engineering and 1 in Civil Engineering. Due to the nature of the Electrical Engineering lab, none of those ten students have longitudinal data sets.

Artifacts were then carefully sorted and categorized by student name (and group member names, in the case of group labs), source university, source course, assignment and academic term of completion. Each artifact was given a coded identifier to ensure student privacy in any reporting outside the research group.

2.2 Research instrument

Multidimensional analysis (MDA), first developed and implemented by Biber [7, 8, p. 145], is a corpus-analysis methodology that utilizes language processing software to analyze text by parts of speech (e.g. nouns, verbs, prepositions, etc.). This analysis is performed at both the word and phrase level. MDA typically identifies six “dimensions” of linguistic features that a text may perform in, and each dimension is rated along a continuum. The dimensions used in this study include Dimension 1: Informational vs involved, Dimension 2: Narrative Quality, Dimension 3: Context dependence, Dimension 4: Overt persuasion, and Dimension 5: Abstract vs. non-abstract information, Dimension 6: Immediate information elaboration. These dimensions have been used to differentiate genres of texts from large corpora (for examples, see the annotated bibliography in [1]), so we have opted to use them to differentiate the textual features of engineering lab reports from other forms of student writing.

The study utilized the Multidimensional Analysis Tagger (MAT) designed by Nini [9]. This software is designed using the Stanford Tagger [10] and Biber’s original algorithms [11], and it includes validated linguistic feature statistics for a variety of text types to provide benchmarks for analysis.

2.3 Multidimensional analysis process

Artifacts were collected electronically from students via consent form and engineering lab instructors. Submissions were not screened by file type: the research team standardized all documents into Microsoft Word format. PDFs and image files were converted using Adobe Acrobat DC’s (Continuous Release, 2020 version) optical character recognition tool.

Word documents were then prepared in two ways for analysis: for whole-text analysis, documents had graphs and other non-text elements removed, then they were converted to plain-text for MAT; for sectional analysis, documents had non-text elements removed, then were divided into multiple files for each declared section (e.g. Introduction, Methods, Findings) before being exported into plain text. First-year composition assignments did not regularly have declared sections, so they were divided using Swales’ [11] definitions of common academic moves.

2.3.1 Text Analysis with MAT

MAT provides a simple interface for both part-of-speech tagging and dimensional analysis. MAT converts the content of plain-text documents into a “tagged” format, with each word clearly labelled by its part of speech, which the analyzer then uses to determine type of text according to types of words used and their order and frequency.

Whole-text documents were analyzed in a single batch using MAT. Statistics for each student’s linguistics features and dimension scores were logged to compare externally to existing text-type statistics (e.g. Academic Prose, Learned Exposition) and to compare internally to measure in-group differences and personal longitudinal change (e.g. “Does this student write *more like an engineer* when in an engineering course?”). Sectional documents were analyzed and logged

similarly, except that all documents retained identifying information to compare them to their whole-text version.

Because artifacts are already identified with a source course and assignment type, MAT statistics were contextualized with an artifact's status as *disciplinary engineering writing* (our knowledge transfer target), *first-year composition* (a vertical transfer knowledge source) or *technical writing* (a horizontal transfer knowledge source), as well as the type of writing assigned to the student (e.g. lab report, argumentative research paper, proposal).

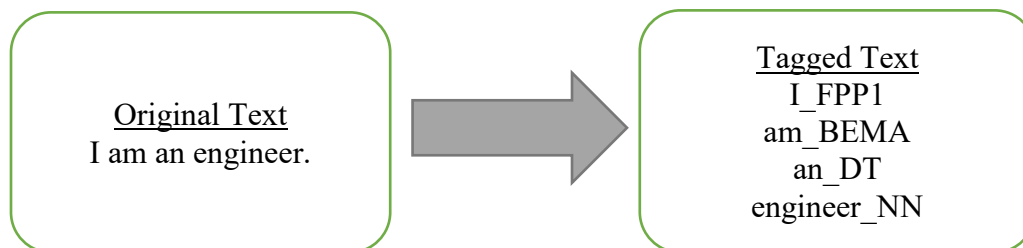


Figure 1: an example of MAT text analysis

3. Results and Discussion

3.1 Genre analysis of writing assignments

3.1.1 Argumentative research paper

28 artifacts submitted were argumentative research papers, a common assignment type assigned in general education writing courses. All document sources listed below are first-year composition courses or courses that perform a similar role in a student's program of study. For our purposes, these are treated as sources of *vertical transfer* knowledge: students have obtained general skills necessary for writing in a variety of courses and situations, but that knowledge is not necessarily connected to a single genre or document type.

Table 1: Argumentative Research Paper Sources

University	Course	Count of Artifacts
University of Portland	PHL 103	1
Washington State University Vancouver	ENGL 100	1
	ENGL 101	5
Oregon Institute of Technology	HUM 125	1
	WRI 121	1
	WRI 122	8
Dual Enrollment/Other University	Dual Enrollment	5
	Writing or English, 100-level	5

In most cases, these courses were taught by full-time faculty. Documents coming from outside the three universities of study either came from courses taught by high school teachers trained to deliver college-level content (Dual Enrollment) or from other colleges and universities that we have no faculty data for.

As an assignment, argumentative research papers are characterized by the presence of multiple cited, external sources and a clear stance that the author intends to defend or convince a reader of. These are typically end-of-term assignments, requiring extensive time to gather resources and synthesize them into a coherent argument on a subject for a broad or general audience. Students are expected to follow the citation conventions of the course professor's discipline (often APA or MLA), as these courses serve as an introduction to citation practices in the general education curriculum. Students are also expected to demonstrate critical thinking skills through synthesis and analysis of external sources, while still maintaining the stance presented in their thesis or conclusion. While students are expected to have enough expertise on their subject to choose appropriate sources, this expertise is typically demonstrated through the sources themselves (and thus the document shows what the student *learned* in research).

Linguistically, these documents are characterized by a high degree of context independence (Dimension 3) as a reader is not expected to already know or be involved with the subject matter. Both of these traits are identified by a low rate of pronouns (demonstrative or otherwise). In our data set, these documents were most closely aligned with Scientific Exposition, expository writing focused on conveying technical and scientific information [9].

3.1.2 Technical Writing

16 artifacts came from technical writing courses, representing a variety of document types, such as technical reports (n = 5), recommendation reports (n = 1) and proposals (n = 3). The broader report category was represented most often, with 8 artifacts altogether. Document sources listed below serve as introductory technical writing courses at their respective universities. WSU Vancouver's technical writing course is 400-level, and many students take it near the end of their program of study. OIT students take more technical writing courses, but its sophomore-level technical writing course, WRI 227, is frequently taken prior to or concurrent with engineering students' first lab course, and it is the only technical writing course from OIT represented here. These courses are treated as sources of horizontal transfer knowledge, as the writing skills taught in these courses are more acutely defined by technical or professional writing genre.

Table 2: Technical Writing Sources

University	Course	Count of Artifacts
University of Portland	-	-
Washington State University Vancouver	ENGL 402	11
Oregon Institute of Technology	WRI 227	4
Dual Enrollment/Other University	WRI 227	1

These documents came from courses staffed typically by full-time faculty. The one artifact from outside our three universities came from an Oregon community college. WRI 227 in the state of

Oregon is designed according to the Oregon Writing & English Advisory Council's general outcomes for the course [13], so we are confident that this student was exposed to similar writing skills as OIT's WRI 227 students.

Assignment types do vary among this set of artifacts, but technical writing assignments share several rhetorical features. The writer is expected to occupy a position of authority or expertise on the subject. While external sources may be present, the writer's authority is expected to come from their existing knowledge (and thus the document is a report of what the writer *knows*). Audiences may be fellow experts or laypersons, but they are narrowly defined to the point that the writer should know what problem they are helping the reader address with their work. Critical thinking is demonstrated by the writer's ability to fully address the audience's needs with minimal extraneous text.

3.1.3 Engineering lab report

35 artifacts were collected from introductory engineering laboratory courses across three majors: civil, electrical, and mechanical. The specific courses were OIT's CE 212, WSU Vancouver's ECE214, MECH309, and UP's EGR270. Most of these courses were instructed by full-time instructors. Lab reports were graded by undergraduate teaching assistants, graduate teaching assistants, and course instructors. Although none of the instructors explicitly specified the report's audience on assignments, it was implied that the audience might be engineering students, engineering instructors, and teaching assistants. The purpose of lab reports is to document student's findings from the lab and communicate their intended technical audience using figures and tables.

Table 3: Engineering Lab Report Sources

University	Course	Count of Artifacts
University of Portland	EGR 270 Materials Lab	6
Washington State University Vancouver	ECE 214 Design of Logic Circuits	16
	MECH 309 Engineering Materials	10
Oregon Institute of Technology	CE 212 Civil Engineering Materials	3

3.2 Linguistics multidimensional analysis of writing assignments

This section describes in more detail what each of the six dimensions represent and what we should expect from artifacts gathered. Here, dimensions are continua, typically rated as demonstrating *more* or *less* of some trait in writing. Definitions below are based on Biber [4] and Nini [5]. Each dimension includes anchor points where we might expect lab reports to perform. Of Biber's [6] text types, we could expect the following as anchor points:

Table 4: Anchor text types [9, p. 7]

Text Type	Characterizing Genres	Characterizing Dimensions	Description
Scientific Exposition	academic prose, official documents	low score on D1, high score on D3, high score on D5, unmarked scores for the other Dimensions	Texts belonging to this text type are typically informational expositions that are formal and focused on conveying information and very technical
Learned Exposition	official documents, press reviews, academic prose	low score on D1, high score on D3, high score on D5, unmarked scores for the other Dimensions	Texts belonging to this text type are typically informational expositions that are formal and focused on conveying information
General Narrative Exposition	press reportage, press editorials, biographies, non-sports broadcasts, science fiction	low score on D1, high score on D2, unmarked scores for the other Dimensions	Texts belonging to this text type are typically texts that use narration to convey information

While these anchors do not provide specific numbers to look for, they do indicate a final expectation:

Table 5: Final expectation of each dimension

Dimension	Low score means	High score means
Dimension 1: Informational / Involved	Informational text. Few pronouns or explanatory notes meant for a known-audience	Involved text. Frequent pronouns or references meant for a known-audience
Dimension 2: Narrative Quality	Text presents information without clear temporal ordering.	Text presents information with clear temporal ordering, like “first,” “next” and “then.”
Dimension 3: Context Dependence	Text requires some contextual knowledge to fully understand.	Text explains contextual factors necessary to understand subject.
Dimension 4: Overt Persuasion	Text presents information in certain or near-certain terms. The author’s stance or perception is not clearly marked.	Text uses modal verbs and other features to indicate probability or lack of certainty. The author’s stance or perception is clear.
Dimension 5: Non-Abstract vs. Abstract Information	Text features concrete and non-technical discussions of subject matter.	Frequent use of technical or abstract prose (typical of scientific discourse).
Dimension 6: Immediate Information Elaboration	Elaboration on noun phrases does not occur within the same sentence as the phrases themselves (explanations are deferred to other parts of the document).	Noun phrases are typically modified or elaborated upon within the same sentence, rather than held for another part of the document.

3.2.1 Dimension 1: Informational / Involved

Ranging from *information dense* (low score) to *highly interactional* (high score), Dimension 1 indicates the ratio of pronouns and verbs to nouns and adjectives. Informationally dense texts tend to be composed of many nominalized phrases [15], while interactional texts will build upon knowledge shared between a speaker (first-person pronouns) and audience (second-person pronouns).

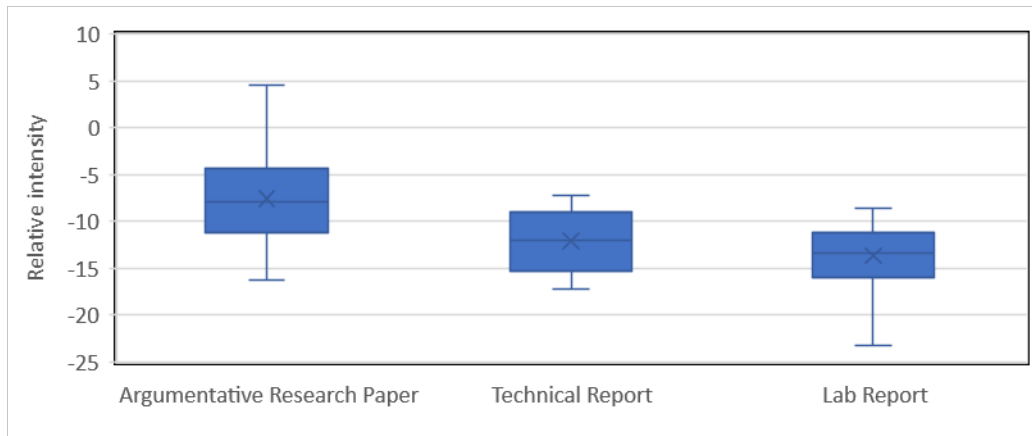


Figure 2: Informational vs. Involved Prose. The box and whisker chart of Dimension 1 (Informational / Involved) ratings of three assignment genres (x point indicates the mean. Box edges indicate the first quartile and the third quartile. Error bars indicate max and min).

As shown in Figure 2, the mean values of argumentative research papers, technical reports, and lab report are -6.5, -12.6, and -12.4, respectively. For reference, Nini [9] scored academic prose at -13.58 and humor at -6.76 (all numbers are in reference to the LOB corpus). Argumentative research papers tend to attempt to connect with an audience in order to persuade them, relying on emphatics, pronouns and statements that require the reader to resolve some ambiguity. In contrast, technical reports and lab reports are highly informational, frequently using direct references to concepts rather than pronouns and simpler, more direct sentence structures. The top 25% of lab report performance in Dimension 1 is close to the bottom 75% of argumentative research paper performance. When writing lab reports, students tried to deliver informationally dense texts to the audience. As writers in these contexts, they have access to some collection of information, mostly lab data, the meaning of which they must explain to and interpret for their audience. Linguistically, students are using a more informational tone in their lab reports than in other genres. Although the assigned argumentative research papers are multi-reference research papers that attempt to change a reader's disposition or activity in some domain, engineering students' argumentative research papers lack much involvement with the target reader. In our data set, we see students clearly moving from more involved to more informational text production in their lab report writing.

3.2.2 Dimension 2: Narrative Quality

Dimension 2 measures the presence of third-person pronouns and past tense verbs. A high rating on dimension 2 indicates a strong narrative quality, while a low rating indicates a lack of narration or many present-tense verbs.

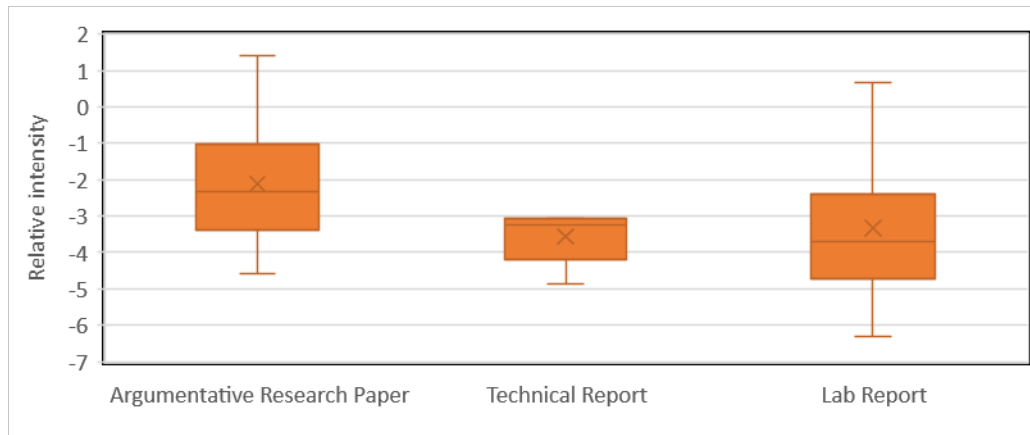


Figure 3: The box and whisker chart of Dimension 2 (Narrative Quality) ratings of three assignment genres

As a genre, the argumentative research paper is more narrative than the other two genres. As shown in Figure 3, lab report has a wide range of Dimension 2 scores. In addition, the mean score of lab report as 2.9 is higher than that of technical report (-3.2), close to Nini's [9] score for academic prose (2.16) and significantly less narrative than fiction (6.26) or press reporting (0.97). Lab report method sections are typically narrative (particularly when detailing a procedure), while argumentative research papers frequently begin or end by narrating temporal connections between data points.

While our data set shows a strong similarity in mean performance across all data types, the technical report document is much more tightly clustered around its average. This distinction is likely due to the nature of WRI 227, as students are carefully guided in the construction of a particular type of report over a full academic quarter, while lab reports are produced to show what students are expected to learn during the academic term.

3.2.3 Dimension 3: Context Independent vs. Context Dependent Features

Ranging from context-dependent (low) to context-independent (high), Dimension 3 measures ratios between nominalizations (indicative of context independence) and adverbs (typical in context-dependent texts). Professional discourse should be context independent; however, students, particularly those in introductory courses, often perform for their teachers [16]. Further, Halliday [15] notes that language with a significant adverb and prepositional phrase use may also indicate a lack of familiarity with the subject matter. Figure indicates that Dimension 3 scores of all three genres are similar, scoring between 4.5 and 5.5, slightly above Nini's [9] score for

academic prose (5.38) and press reviews (5.38). These documents are written for audiences that may not be familiar with all of the context of a subject or situation and should not be required to research that information on their own.

Again, as with narrative quality, there is little indication of major shifts from first-year composition into lab report writing, but technical report writing classes (WRI 227) seem to enforce a particular level of context independence.

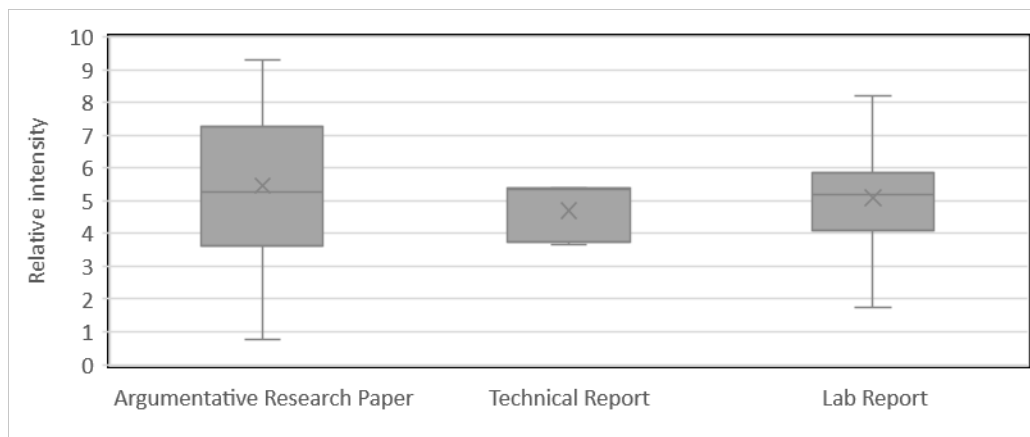


Figure 4: The box and whisker chart of Dimension 3 (Context Independent vs. Context Dependent Features) ratings of three assignment genres

3.2.4 Dimension 4: Persuasion vs. Non-Persuasion

Dimension 4 measures the amount of modal verbs (e.g., could, should, may, might, and other verbs showing ability or likelihood) and other features indicating persuasion in the sense that the rhetor is trying to convince the audience of a phenomenon’s possibility or desirability [17]. Figure shows that the lab report genre has the lowest mean score (-1.8), while the mean scores of argumentative research papers and technical reports are 1.0 and 0.1, respectively. For comparison, the lab report scored similarly to press reviews in Nini [9] (-2.32), while research papers and reports were somewhat less persuasive than press editorials (3.3). Students used persuasive language (in the sense of conveying possibility or uncertainty) more often when writing an argumentative research paper than a lab report. Unless students are suggesting possible explanations for data, lab reports should be expected to show even lower scores on Dimension 4—a lab report requires students to show that they understand course material and disciplinary analytical procedures, which primes students to perform a greater level of certainty than is often called for in professional settings.

As Biber and Conrad [1, pp. 161-162, 8] note, modal verbs are important in practitioner writing to reduce potential liability. These modals are used with a greater degree of precision (e.g., “the member is likely to fail if exposed to temperatures below 4 °C”) than seen in most student writing. This prediction is based on Biber and Conrad’s [1] finding that students typically associate persuasion and “weasel words” (verbs indicating uncertainty, for example, “may,” “can be,” “help,” “believe”) with poor analysis or low confidence.

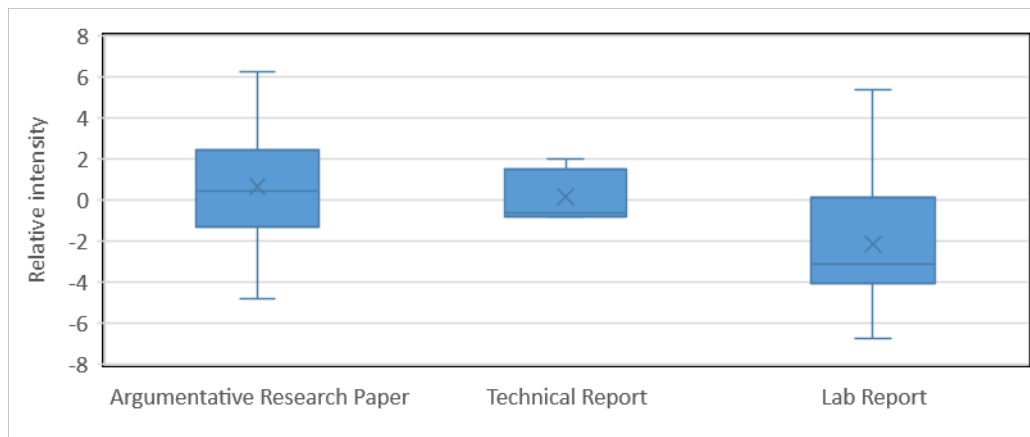


Figure 5: The box and whisker chart of Dimension 4 (Persuasion vs. Non-Persuasion) ratings of three assignment genres

3.2.5 Dimension 5: Abstract vs. Non-Abstract Language

High scores on Dimension 5 indicate many passive clauses (such as passive voice verb usage) and conjunctions, typical of representing concrete/non-abstract information or associating otherwise concrete concepts in novel ways. The focus of this language tends to be on phenomena observed and actions taken, with less focus on the actors in those situations.

As shown in Figure 6, we are unlikely to find a pattern within Dimension 5 in the three document groups. The middle 50% performances of three genres are almost identical at approximately 2.1. A much lower variation of technical report scores belongs to the small sample size. The similarities in Dimension 5 scores suggest that all these writing assignments do not explicitly require a level of abstract language, and thus engineering students perform as they usually would in an academic context.

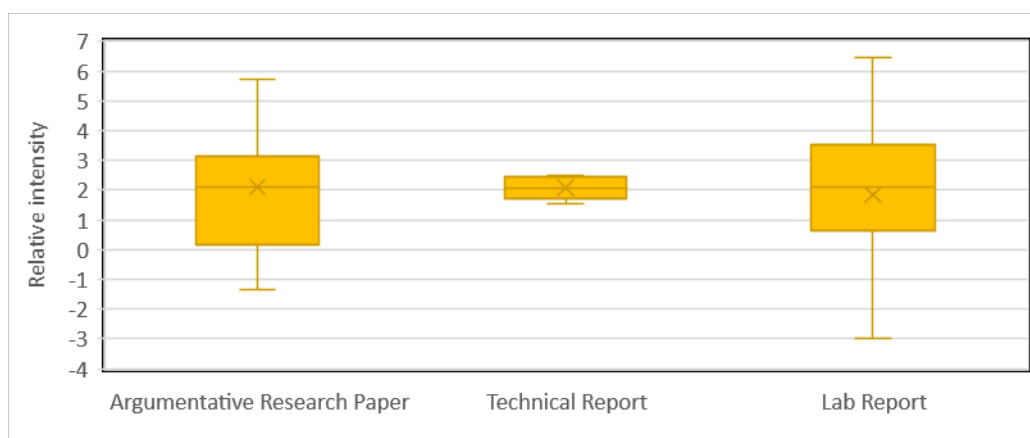


Figure 6: The box and whisker chart of Dimension 5 (Abstract vs. Non-Abstract Language) ratings of three assignment genres

3.2.6 Dimension 6: On-Line Elaboration vs. Deferred Elaboration

Dimension 6 indicates the proximity of elaboration phrases (e.g. subordinated clauses, prepositional phrases) to the core nouns and phrases they explain. A high rating in this dimension is typical of extemporaneous language (e.g., texts used in speech, emails). A low rating indicates a document where elaboration may occur far before or after a concept is raised (e.g., texts used in formal reports).

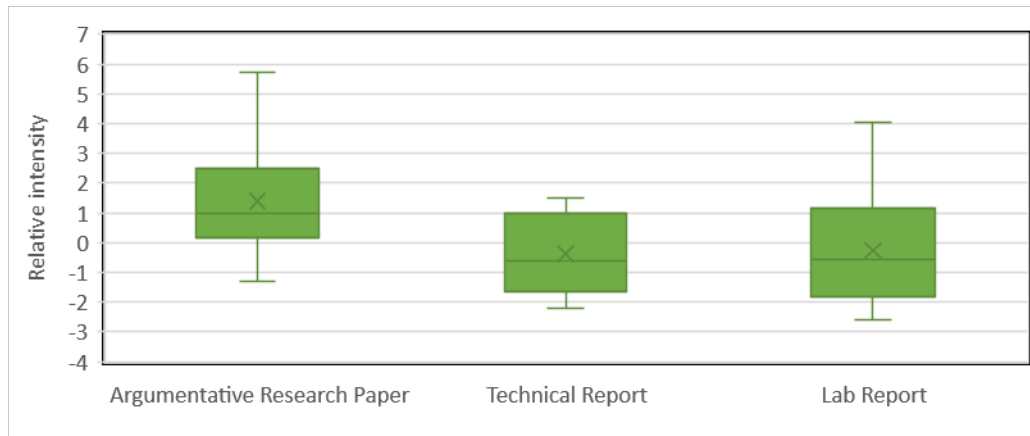


Figure 7: The box and whisker chart of Dimension 6 (On-Line Elaboration vs. Deferred Elaboration) ratings of three assignment genres

Figure 7 shows that the mean and the first and third quartile scores are almost identical between technical reports and lab reports, and they are lower than those of argumentative research papers. The middle 50% of lab report and technical report performances in Dimension 6 is even lower than the bottom 75% of argumentative research paper performance. Engineering students elaborated highly before or after a concept is raised when writing technical reports and lab reports. The highly-structured nature of a lab report forces writers to separate elaboration from claims (e.g. separating Results from Discussion), while first-year composition courses often enforce a model of explaining data (typically externally referenced material) immediately after implementing it (e.g. [18]). The relatively minor shift towards deferred elaboration document-wide is more noticeable when documents are analyzed by section.

In the equivalent of a Methods move in argumentative research papers, students are much more frequently adding elaboration to their sentences' core noun-phrases—typically to explain why some references were consulted or what the reasoning was for choosing a particular topic. In contrast, technical reports in WRI 227 are taught to use as much information segregation as possible, leaving students with few opportunities to elaborate on a noun phrase in the moment. The lab report genre, on the other hand, is far more mixed: Methods sections tell readers to wait for results and analyses until later in the document, while Results sections omit elaboration on collected data. Far more elaboration occurs in Conclusion and Introduction sections, scoring higher in on-line elaboration than Nini's [9] highest scoring text type, religious text (which frequently elaborates on the nature of divine individuals or beings within the sentence they are declared).

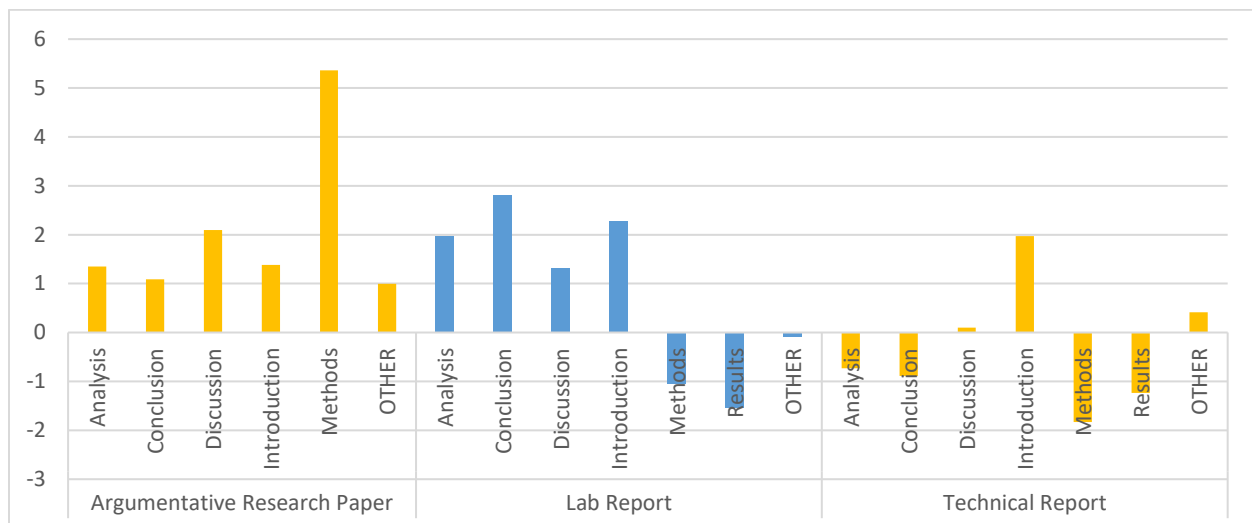


Figure 8: Deferred vs. On-Line Elaboration by Document Section

3.3 Discussion

We can characterize the writing assignments often given to engineering students during the first two years of study in college, as shown in Table 6. Students' argumentative research papers in academic writing courses, mostly first-year-composition courses, are highly involved, highly persuasive, and used deferred elaboration. In contrast, engineering lab reports are highly informational, narrative, minimally-persuasive, and featured more immediate elaboration on claims and data. We had a group of students who took technical communication or technical writing courses in their sophomore year. Their technical reports are informational, persuasive, minimally narrative, and used immediate elaboration, which is quite similar to lab reports. All three genres were context independent and minimally abstract, which are typical characteristics in academic writing.

The analyses above indicate that students are generally performing as expected in lab report writing in entry-level engineering lab classes, and that this performance is markedly different from their earlier academic writing courses, mostly first-year-composition, indicating that it cannot be expected that engineering students are not already "writing like engineers" after completion of their first year at college. However, similarities in context independence and non-abstract language across course contexts suggest that engineering students must still learn to modulate their languages in writing dramatically depending on the writing assignment. When students experience Another academic writing course including technical communication or technical writing, it can contribute to engineering students' readiness for engineering literature writing due to the similarities between technical report and lab report. In Dimensions 1, 2, 4, and 6, the student performance mean and range of technical report were placed between argumentative research paper and lab report. Writing experiences of technical reports can be expected to enhance engineering students' ability to change their register or other linguistic/structural features to meet the expectations of the range of audiences.

Table 6: MDA analysis result comparisons among three writing genres

		Argumentative research paper	Technical report	Engineering lab report
Genre analysis	Courses	First-year composition	Technical writing	Introductory level engineering labs
	Typical writers	Mostly first-year students	Mostly second-year students	Mostly second-year students
	Typical audience	College students in any major	College students in any major	Engineers, college students in engineering majors
	Typical purpose	To defend an assertion or convince an audience of an interpretation of data	To document a concept or procedure fully enough that a known audience could solve a known problem with this information	Convey lab process, analysis/synthesis/evaluation of lab data/products, and related engineering principles to a technical audience.
Dimensions	Dimension 1: Informational / Involved	Involved	Informational	Informational
	Dimension 2: Narrative Quality	Narrative	Non-narrative	Non-narrative
	Dimension 3: Context Dependence	Context independent	Context independent	Context independent
	Dimension 4: Overt Persuasion	Highly persuasive	Persuasive	Less persuasive
	Dimension 5: Abstract vs. Non-Abstract Information	Non-abstract	Non-abstract	Non-abstract
	Dimension 6: Immediate Information Elaboration	Deferred elaboration	Immediate elaboration	Immediate elaboration

4. Conclusion

This article presents an insightful investigation on the linguistic feature characteristics of multiple writing assignments completed by engineering undergraduates. Three academic writing genres were chosen for the analysis: argumentative research paper from first-year composition, technical report from technical communication, lab report from entry-level engineering laboratory courses. Biber’s multidimensional analysis (MDA) method was used as the analysis tool for the student writing artifacts (n = 68). MDA scored six “dimensions” of linguistic features that a text may perform in each student writing artifact. The results indicate that engineering students’ argumentative research papers, mostly in their first-year composition courses, are highly involved, highly persuasive, and used deferred elaboration. In contrast, engineering lab reports are highly informational, narrative, minimally-persuasive, and featured more immediate elaboration on claims and data. Although technical reports’ MDA dimensional scores range between those from argumentative research papers and lab reports, technical reports are also informational, persuasive, minimally narrative, and used immediate elaboration, which is similar to lab reports. All three genres are context independent and non-abstract, which is typical for writing in an academic setting. The analyses above indicate that students are generally performing as expected in lab report writing in entry-level engineering lab classes. Similarly,

they are typically performing differently in their earlier academic writing courses such as first-year-composition (FYC) and technical communication/writing. However, it also indicates that engineering students need to—and frequently make some attempt to—change their language in writing dramatically depending on the writing assignment.

5. Acknowledgement

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