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ARTICLE

A Corpus-Based Comparative Analysis of Vocabulary and Paratext in Design and Engineering Design Articles

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ABSTRACT

This study is an attempt to understand some of the differences between Design and Engineering Design disciplines. Linguistic studies in the field of design are rare and there are no studies in the literature that compare vocabularies in different design disciplines. A Design corpus of 112 research articles with 995,318 words and an Engineering Design corpus of 95 articles with 1,262,264 words were used to compare differences in vocabulary and paratextual features. The work is based on discourse communities proposed by Swales. The findings demonstrate that a comparative quantitative vocabulary analysis is a reliable tool to compare and contrast keywords and terms specific to each discipline. Results indicate that each discipline has developed its own specific vocabulary, which can be statistically identified using lexical analysis software and comparison with a reference corpus. Words including human, user, and experience were determined to be keywords in Design, while model, problem, and number are keywords in Engineering Design. The most prominent differences in terms of paratext are the use of equations and tables in Engineering Design articles and the frequent use of photographs in Design articles. It is argued that these marked differences, especially in paratext, are due to different epistemologies, academic traditions, and historical origins in each field.

Keywords: Vocabulary; Keyword; Paratext; Engineering Design; Design; Corpus Linguistics

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1. Introduction

Design and Engineering Design are two independent disciplines, although they are closely linked. They have different historical roots and different approaches to knowledge generation. While Engineering Design is based on a positivist epistemology, Design is commonly accepted to be part of social sciences and relies on various epistemologies including social constructionism, subjectivism, post-positivism, and the design epistemology.

To guide readers who are not acquainted with the two disciplines under scrutiny, some definitions of Design and Engineering Design will be provided, reminding them that there are many other definitions available for both.

Buchanan [1] defines the term design as follows: "The central theme of design is the conception and planning of the artificial. Design provides the thought which guides the making of all products, whether by individual craftsmanship or mass-production techniques: (1) material objects, (2) verbal and visual communications, (3) organized activities and services, and (4) complex systems or environments for living, playing, working, and learning."

Design is an activity that is a natural result of the human thought process. People who try to solve problems use their creative design skills, even if they did not get a design education. Therefore, it may not be surprising that the term design has become very common, almost to the point of banalization. Popular examples of the term include hair design, floral design, career design, and even human design. From an academic perspective, design is a broad term that covers several fields such as fashion design, industrial design, interior design, graphic design, and architecture. The boundaries of these fields may overlap to a certain extent.

According to ABET [2], "Engineering design is a process of devising a system, component, or process to meet desired needs and specifications within constraints. It is an iterative, creative, decision-making process in which the basic sciences, mathematics, and engineering sciences are applied to convert resources into solutions." The acronym ABET stands for the Accreditation Board for Engineering and Technology. ABET is an internationally renowned organization, originally founded for the education, accreditation, regulation and professional development of engineering professionals and students in the United States. Since the organization is dedicated to accreditation and regulation, this definition is acceptable for the purpose of our present discussion.

This study, following the footsteps of register analysis [3], begins with a basic assumption that these two disciplines employ different registers with respect to textual and paratextual features. In this regard, it is assumed that the terms and paratextual features used in Engineering Design and Design research articles, their context and frequency will differ from each other. In linguistics, register is a term that represents functional language variations regarding characteristic lexico-grammatical features [3–5]. Register analysis focuses on the linguistic features of a particular field [6]. Here, we focus on a register subcategory, namely academic articles in a specific discipline [7]. Register analysis can use quantitative, qualitative, automated, or combined approaches. In the present study, we mostly depend on quantitative methods, although some qualitative analysis was required to understand the context of various terms.

The aim of the present study is twofold: to assess the vocabulary of each discipline as manifested in research articles with corpus linguistic techniques and to analyze paratextual features such as photographs, footnotes, tables, or graphics. This study, to the best of our knowledge, is a first attempt to compare and contrast two design fields that are closely knit, through lexical and paratextual analysis of academic articles.

Our main hypothesis is that research articles published in Engineering Design and Design journals will vary with respect to the linguistic resources they utilize. If there is a significant difference in the respective academic articles of each field, text analysis software should clearly show it. Such an endeavor is important for a variety of reasons. The results of this analysis will contribute to the understanding of keywords and the development of previously generated vocabularies of each discipline. Identification of keywords related to a discipline, among other reasons, is crucial to conducting word mining and text-based search on the Internet and in electronic documents. Furthermore, the present study investigates the links between epistemology and vocabulary, which may have important practical and theoretical implications in academic writing on Design or Engineering Design. One of our aims is to contribute to the analysis and comparison of academic vocabulary specific to Engineering Design and Design registers.

A further aim of the present study is to analyze paratextual features used in respective corpora. While there are some studies analyzing acknowledgements, dedication, keywords, and titles as paratext[8–10], other types of paratext such as tables and figures have been rarely analyzed, if at all. This part of the study uses a quantitative comparison regarding paratext, including charts, footnotes, equations, tables, illustrations, and photographs. All academic articles published during 2019 and 2020 in the *International Journal of Design* and *The Design Journal* (representing the field of Design), as well as *Journal of Engineering Design and Research in Engineering Design* (representing the field of Engineering Design), were analyzed for this study. Details of the corpora can be found in the Methods section.

Design terminology is not well established so far and studies on Design/Design Engineering vocabulary are very rare. It is not clear which keywords represent Design Engineering and set it apart from Design alone. A better understanding of design terminology, keywords, and vocabulary would contribute to the development of discourse in design practice, publications, and education. Furthermore, clarification and consensus in terminology are essential for document search, text mining, artificial intelligence, and bibliometrics. The prospective contributions of the present study thus lie in all these fields and practical applications.

Based on the aims clarified above, the following research questions (RQs) have been established:

RQ1: What are the statistical differences in vocabulary between Engineering Design and Design publications?

RQ2: What is the link between common keywords and the two disciplines of design?

RQ3: What are the major paratextual differences between articles published in Engineering Design journals and Design journals?

The combined use of vocabulary and paratext analysis across design disciplines, and the employment of comparative quantitative lexical analysis, brings a novel contribution to the fields of applied linguistics and design studies.

2. Linguistic Studies in the Fields of Design, Design Engineering, and Architecture

2.1. On Design and Engineering Design

Unlike engineering, whose origins can be traced back to ancient civilizations, Design is a relatively new field with professional roots starting in the first half of the 19th century in Europe. One of the first schools that contained "design" in its name rather than "applied arts", "decorative arts", or "industrial arts" was the Government School of Design established in 1837 in London[10,11]. However, the establishment of Design as well as Engineering Design as independent disciplines occurred much more recently. The first conference on design methods which took place in London in 1962 is regarded as a turning point in the emergence of novel and "scientific" approaches to design. Books about design methods first appeared in the 1960s while journals dedicated to Design and Engineering Design started to appear after 1979[12].

One of the clear indicators of a discipline is the presence of books and articles dedicated to it. According to Swales[13], a distinguishing feature of a discipline is the existence of a publication venue where members of a discourse community can share their findings. Swales[13,14] has put considerable effort into the analysis and discussion of what constitutes genre and discourse communities. In his later work, he transformed his earlier notion of "discourse community" into "place discourse community", which refers to a group of people who interact with each other and use a range of spoken, spoken-written, and written genres[14,15]. These communities provide the opportunity to communicate and gradually acquire the specific know-how, terminology, and discourse competency to be accepted as a new member[14,16,17]. Within this context, a discipline can be defined as a language-using community that helps to join writers, texts, and readers[16]. Scientific or academic disciplines develop their specific terminology and use various mechanisms of intercommunication among their members. A common venue of communication between members of a certain academic discipline is the scientific journal where research articles are published.

Historically, the first two Design journals in English were Design Studies and Design Issues, introduced in 1979 and 1984, respectively. Similarly, the first two Engineering Design journals were Research in Engineering Design and Journal of Engineering Design, introduced in 1989 and 1990, respectively[12].

Design has evolved from at least two different cultures, namely engineering and arts, or at a larger scale: the humanities and the sciences[18,19]. This dichotomy can still be found in the educational style of design schools with an artistic reputation and those with a more technical or industrial approach. The former stresses issues such as aesthetics and semiotics, whereas the latter focuses on functional and industrial features of a product.

Following the tradition of the scientific method, Engineering Design is based on positivist research perspectives [20]. On the other hand, contemporary design is involved in issues such as product aesthetics, human needs, experience, pleasure, satisfaction, social awareness, and environmental responsibility. The field of design uses both post-positivist as well as qualitative research perspectives.

2.2. Linguistic Features of Design, Engineering Design, and Architectural Discourse

A relatively small number of articles are available on specific linguistic features of Design, Engineering Design, or Architecture-related discourse. A few studies have been published about the semiotics of architectural writing [21,22], which fall outside the domain of this article. Swales et al. [23] discussed their efforts to develop an English for Academic Purposes (EAP) course for Master's of Architecture students at a major US university. In most undergraduate and professional master's design courses, the studio is the core of design education. The main challenge for these particular students was to make a good presentation in front of the final jury for the design studio. Another challenge was academic reading and writing. The EAP course aimed to develop some strategies for effective presentations and improved reading and writing skills.

In addition to traditional EAP tasks that focus on language development, the course also aimed to raise awareness of architectural terms such as drop ornament, pendant, cross-window, transom, and mullion. An interesting strategy was to ask international students to contribute to a hypothetical international dictionary of architecture by defining terms important to explain the architectural heritage of their own country.

Dannels [24] used an ethnographic approach focused on assigned meaning to oral presentations at a design school. The study involved observations of student presentations at five undergraduate design departments under the College of Design at a large southeastern US university and interviews with faculty members. Four distinct types of oral genres were identified, which are variations of oral student presentations that took place throughout the semester. Interviews with faculty members helped to identify certain skills needed to succeed in such presentations. One of these skills was to illustrate command of design jargon. According to faculty members, students need to learn the specific design vocabulary in their field and use it in their presentations. Furthermore, they need to be able to translate these specific terms to daily language in cases where the audience is an outsider to the design field, for example, a client who commissions a design project.

Morton [25] investigated the verbal presentations of architecture students from a large Australian school throughout one semester. Successful and unsuccessful presentations by first-year and fourth-year students were analyzed. The case study investigated strategies used by students with different presentation skills and identified the modes chosen for more successful presentations, their grammatical and lexical components, and the generic levels included in the presentations such as site description, design concept, and design details. According to Morton, a successful presentation uses a range of rhetorical strategies to contextualize one's design, which conveys the richness and complexity of ideas associated with the design and helps the audience to visualize the project.

Caballero [26,27] analyzed the language used by architects to describe spatial organization and built space through metaphors based on publications selected from the architectural review genre. According to Caballero, various metaphorical approaches used in these publications include:

- Image metaphor (e.g., meander, ring, bubble, skeleton);
- Conceptual metaphor (e.g., "under its skin the library is a great machine");
- Sensorial metaphor (e.g., the use of aural lexis such as quiet, mute, jarring, or the use of tactile lexis such as fragile, whipping, crisp).

Lloyd [28] applied ethnography to investigate the development of discourse in the Engineering Design process. This study shows that a common narrative is built with reference to shared experiences in a particular organization through the mechanism of storytelling. Here, storytelling refers to narratives, experiences, or explanations about a certain event in the context of a design project or a design specification. In the Engineering Design organization, complex social and technical scenarios are deconstructed and reconstructed into words, phrases, or abbreviations. A new language is invented to describe the ongoing experience of the new product. The product identity that emerges during the design process is based on stories, words, and phrases that are told about it.

Atcheson[29] compared lexical bundles in academic articles published in the fields of photography, audiovisual arts, and product/industrial design. The corpora comprised 30 published articles from each discipline. Both qualitative and quantitative (software-based) corpus analysis were used following Biber et al.'s[30] formal taxonomy and Hyland's[31] functional taxonomy models. It was found that texts in the discipline of product/industrial design contained significantly more lexical bundles than the other two disciplines that were analyzed. Two of the most frequently used content-oriented lexical bundles in product/industrial design were "of the design process" and "in the development of". Unlike photography and audiovisual arts, greater utilization of hedging or boosting language and distancing occurred in product/industrial design texts, suggesting an alignment with technical and hard science disciplines, indicating that product/industrial designers have a closer affiliation with technical fields.

Our literature survey indicated that most of the available publications on the linguistic features of Design focus on discourse and oral presentations in studio settings or in Engineering Design companies. Notably, there is a big gap in the literature related to studies on Design vocabulary.

2.3. Specialized Vocabulary and Paratext

Domain-specific academic vocabulary is a term that refers to words used in a given discipline such as biology, geometry, or chemistry. Each discipline or profession uses certain technical terms that are restricted to itself. The number of such technical terms may be relatively low in certain academic disciplines such as business and engineering or quite expansive in others such as natural sciences[4].

Discipline-specific (or subject-specific) vocabulary is defined as lexical items which tend to occur frequently in texts of one discipline and appear infrequently in other texts[32,33]. Discipline-specific terms or technical vocabulary form the core of discipline-specific vocabulary. For example, the word facade is an architectural term used to describe the front side of a building. Semi-technical (or sub-technical) vocabulary is accepted to be a second layer within subject-specific vocabulary[34]. Semi-technical terms are not as specific to the respective field as technical terms. Baker[35] has described six types of terms that are considered semi-technical by linguists. For instance, words that have a specialized meaning in one or more disciplines but a different meaning in general language, or words that are not used in general language but have different meanings in a specific discipline, are respected as semi-technical terms. Terms such as apron and taxi are semi-technical terms used in the field of aviation[34].

Yitzhaki[36–38] studied various aspects of journal article titles. He proposed the term substantive words[36] which he later named significant words[38] to describe non-trivial words within a text. Significant words are defined as "untrivial words not included in a stoplist of trivial words such as: to, the, of, etc. (i.e., articles, prepositions, conjunctions, pronouns and auxiliary verbs)." The number of significant words has been used by Yitzhaki as a measure of the informativity of a journal title.

Another important term used in the domain of corpus linguistics is keyword (also used in the form key word). Scott[39] defined the term key word as "a word which occurs with unusual frequency in a given text", where "unusual" is used in the sense of unusually high or low frequency compared to a reference corpus. Scott's study was based on statistical procedures built into WordSmith text analysis software (which was developed originally by the same author), but keywords have much broader appeal now. The qualitative approach to keywords suggests that a word is key only if a scholarly, interpretive investigation indicates its keyness[40]. Lien[41] studied the religious terminology using multilevel keyword analysis in a compilation of Buddhist corpus. The corpus, made up of approximately 22.7 million tokens, was gathered from publicly available books, e-books, and journal articles. The procedure for keyword extraction involved a combination of statistical tools (keywords tool of WordSmith 6.0), reassessment using dictionaries, and identifying word families for selected keywords. It was demonstrated that multilevel keyword analysis is more effective for the identification of high-frequency keywords than using a single statistical approach. The current study will use the approach taken by Lien[41], which is based on keyword analysis in a specialized corpus.

Nusir et al.[42] used text mining procedures in order to establish the most commonly used keywords in design research and to analyze temporal changes in the use of these keywords. They also used generated keyword clusters that show closely related keywords. Their study created a dataset of keywords collected from articles published between 2007 and 2019 in ten journals related to design. Their analysis did not make any distinction between Engineering Design and Design. The top five keywords with the highest frequency within the dataset were design education, design, creativity, product design, and co-design.

Huang et al.[43] analyzed a corpus derived from the journal Industrial Design that has been published in Taiwan since 1967. The study used the Python programming language. The term frequency-inverse document frequency (TF-IDF) algorithm was used to determine the most frequently used keywords during three different periods (1960s–1980s, 1990s, and 2000–2022) with the aim of pinpointing key research topics. Categorization according to topic areas indicated that the main research topics during these periods were design planning and strategy, design theory, and perception and preference research, respectively.

According to Genette and Maclean[44], a text is always accompanied by a certain number of verbal or nonverbal productions such as a title, the author's name, a preface, and illustrations, for which he coined the term paratext. This term represents any material additional to the core text that has functions such as explaining, instructing, or supporting. Common examples of paratext include footnotes, endnotes, abstracts, contents pages, indexes, titles and subtitles, tables, charts, and diagrams[45]. Cronin and Franks[8] explored formal and informal modes of collaboration in life sciences research through paratextual data, derived from acknowledgments and bylines. Their analysis of more than 1,100 acknowledgements revealed the scale and scope of collaboration between scientists. Similarly, Salager-Meyer et al.'s[9] study focused on the acknowledgement paratext of medical research papers with the aim of comparing publications from three different countries, i.e., Venezuela, Spain, and the USA. Several features were compared such as acknowledgement frequency and length, named vs. unnamed acknowledgement, and type of funding. The present author is not aware of any study that compares paratextual data in publications from different disciplines.

3. Methods, Tools, and Scope of Research

The corpus used in this study was composed of all academic articles published in 2019 and 2020. These two years were representative of recent literature in four journals; two dedicated to Design (*Design Journal* and *International Journal of Desig*n) and two to Engineering Design (*Journal of Engineering Design* and *Research in Engineering Design*). These four journals were selected since they are the most established ones in their respective fields (see Section 2) and they are among the ones with the highest ranking in citation databases. The analysis was limited to a two-year period since a larger dataset caused malfunction of the available software. The years 2019 and 2020 were suitable for the purpose of this study based on the continuity of issues of publication and the relatively low number of special issues which could otherwise cause bias and incorrect results.

The Design corpus contained 112 articles with 995,318 total words. The Engineering Design corpus contained 95 articles with 1,262,264 total words. Abstracts and references were also included in the analysis. The study was limited to two years since a larger corpus started to slow down the selected software, as explained below.

Vocabulary assessment involved the online text analysis tool Voyant[46] to determine the most frequently used words and their availability in different documents. Digital copies of articles were downloaded in PDF format and uploaded to the Voyant website. Two other software, namely Textalyser[47] and WordSmith[48], were used to confirm the results derived by Voyant. All three tools provided very similar results in terms of word frequency. Initially, a top-100 list for each corpus was created. Plural forms (study/studies) and conjugations of verbs (show/shown) were combined. After this step, a top-40 list was created for both corpora.

As pointed out by Lien[41], frequency of keywords alone is not sufficient to indicate significance or keyness. The significance of words and their roles in the corpus can be determined by comparing two types of corpora: specialized, which is the one analyzed, and general, which contains words from a much larger, non-specific database. To make this comparison, the COCA Core Academic Vocabulary List was used. This is a selection of 3,000 words from the more general COCA list of 120 million words, which in turn is derived from the Corpus of Contemporary American English (COCA) that contains 425 million words [49]. Each of the words in the top-40 list from both disciplines (Design and Engineering Design) were manually searched in the COCA list and those that were available were listed in terms of rank and frequency (**Tables 1** and **2**).

Table 1. Comparison of frequency (% of total number of words) of top 40 terms derived from publications in the Design discipline and general academic vocabulary (COCA-Acad) word list.

Design			COCA-Acad			
Rank	**Word**	**Frequency %**	**Rank**	**Word**	**Frequency %**	**Rate Ratio**
1	Design	1.53	127	design	0.022	69.5
2	Research	0.36	7	research	0.003	90.0
3	Journal(s)	0.25	278	journal	0.012	20.8
4	Use(s)	0.17	13	use	0.053	3.3
5	Process	0.27	553	process	0.006	46.7
6	New	0.21		-		-
7	Different	0.13		-		-
8	Data	0.13	15	data	0.053	2.5
9	Based	0.12	51	base	0.035	3.7
10	Used	0.11	13	use	0.054	2.2
11	University	0.10	21	university	0.048	2.1
12	Understanding	0.08	161	understanding	0.019	4.7
13	Figure(s)	0.16	46	figure	0.036	0.5
14	Work(s)	0.14		-		-
15	Practice(s)	0.17	38	practice	0.040	4.5
16	Time(s)	0.11		-		-
17	Action(s)	0.10		-		-
18	Using	0.08		-		-
19	Approach(es)	0.12	71	approach	0.030	4.3
20	Designer(s)	0.27		-		-
21	Development(s)	0.10	14	development	0.053	2.1
22	Human(s)	0.10	25	human	0.045	2.4
23	Example(s)	0.10	122	example	0.022	4.3
24	Study(ies)	0.25	1	study	0.114	2.3
25	Social	0.12	4	social	0.083	1.4
26	Way(s)	0.11		-		-
27	Information	0.10	16	information	0.051	1.9
28	Technology(ies)	0.11	54	technology	0.033	3.2
29	Case(s)	0.09		-		-
30	Making	0.08		-		-
31	Experience(s)	0.21	23	experience	0.047	4.7
32	Knowledge	0.13	66	knowledge	0.030	4.5
33	People	0.09		-		-
34	Method(s)	0.12	85	method	0.027	4.3
35	Analysis	0.09	37	analysis	0.040	2.2
36	User(s)	0.23	281	user	0.012	19.2
37	Value(s)	0.12	809	value	0.003	32.5
38	Product(s)	0.31	84	product	0.027	11.4
39	Interaction(s)	0.12	218	interaction	0.015	8.7
40	Group(s)	0.11	1,339	group	0.001	60.0
	TOTAL	7.31			1.34	

Table 2. Comparison of frequency (% of total number of words) of top 40 terms derived from publications in the Engineering Design discipline and general academic vocabulary (COCA-Acad) word list.

Engineering Design			COCA-Acad			
Rank	**Word**	**Frequency %**	**Rank**	**Word**	**Frequency %**	**Rate Ratio**
1	Design	1.35	127	design	0.022	62.3
2	Product(s)	0.46	84	product	0.027	16.8
3	Process	0.39	553	process	0.006	70.5
4	Engineering	0.39		-		-
5	Study(ies)	0.22	1	study	0.114	2.0
6	Based	0.21	51	base	0.035	6.0
7	Analysis	0.19	37	analysis	0.040	4.8
8	Research	0.19	7	research	0.003	57.7

Table 2. *Cont.*

Engineering Design			COCA-Acad			
Rank	**Word**	**Frequency %**	**Rank**	**Word**	**Frequency %**	**Rate Ratio**
9	Used	0.17	13	use	0.053	3.2
10	Approach(es)	0.16	71	approach	0.030	5.3
11	New	0.13		-		-
12	Related	0.08	533	related	0.006	13.6
13	Different	0.14		-		-
14	Use(s)	0.13	13	use	0.053	2.5
15	Support	0.08	67	support	0.030	2.5
16	Model(s)	0.34	779	model	0.003	104.3
17	Development(s)	0.16	14	development	0.053	3.1
18	Case(s)	0.16		-		-
19	Time(s)	0.15		-		-
20	Example(s)	0.14	122	example	0.022	6.2
21	Specific	0.08	108	specific	0.024	3.2
22	Data	0.18	15	data	0.053	3.5
23	Information	0.15	16	information	0.051	2.9
24	Result(s)	0.15	189	result	0.017	8.9
25	Number(s)	0.13		-		-
26	Method(s)	0.19	85	method	0.027	6.9
27	Value(s)	0.17	809	value	0.003	57.6
28	Work(s)	0.13		-		-
29	Problem(s)	0.17		-		-
30	Requirement(s)	0.16	292	requirement	0.011	13.8
31	Level(s)	0.13	8	level	0.065	1.9
32	Table(s)	0.12	19	table	0.049	2.5
33	Show(n)	0.11		-		-
34	System(s)	0.33	3	system	0.091	3.6
35	Knowledge	0.14	66	knowledge	0.030	4.7
36	Figure(s)	0.12	46	figure	0.365	0.3
37	Structure(s)	0.10	96	structure	0.026	3.9
38	Quality	0.09	113	quality	0.023	3.9
39	Propose(d)	0.08	378	propose	0.009	9.4
40	Function(s)	0.17	589	function	0.005	32.9
	TOTAL	8.13			1.34	

The context, collocation, and particular meaning of some words (especially terms with multiple meanings) were analyzed by manually searching for the word within the text and inspecting several examples of their use. The occurrence of paratextual features was determined from the same corpus used for vocabulary assessment. These features were analyzed and counted without the aid of specific software. Consistency was ensured using a double-check procedure. The definitions of each paratext item such as formula, equation, chart, and graph were based on online dictionaries [50,51].

4. Results

Vocabulary

Table 3 lists the top 40 words used in publications in the fields of Engineering Design and Design, respectively, in order of frequency. This is a small but significant part of the overall database that lists more than 1,000 words according to frequency of occurrence. **Figure 1** shows the percentage and spread of the top 26 words for each discipline. Frequency indicates the number of times the term was used in the respective corpus. A more reliable indicator is %, which indicates the frequency as a percentage of the overall text tokens. The right-hand column shows the number of articles in which the respective term was detected. In this study, this will be called spread. This is another indication of how widespread a term occurs in research articles. The bold words are terms listed only in the top 40 of one of the respective corpora (e.g., Design) and not in the other one. For example, human, people, and social are terms that are listed in the top 40 in the case of Design while they are not listed in Engineering Design. Similarly, the terms support and model are present in the top 40 of the Engineering Design list but not so in the case of Design. This may be an indication that human, people, and social are terms more specific to the field of Design rather than Engineering Design. The high frequencies of use

(0.10, 0.09, and 0.12%, respectively) and the good distribution of the respective terms in design-related publications (used in 103 and 102 articles, respectively) suggest a strong link between these terms and the field of Design.

Table 3. Top 40 terms used in academic articles in the fields of *Design* and *Engineering Design* published in 2019 and 2020.

	Design				Engineering Design			
N	**Word**	**Freq.**	**%**	**Spread**	**Word**	**Freq.**	**%**	**Spread**
1	Design	15,185	1.53	112	Design	16,991	1.35	95
2	Research	3,537	0.36	112	Product(s)	5,831	0.46	95
3	Journal(s)	2,477	0.25	112	Process	4,962	0.39	95
4	Use(s)	1,704	0.17	112	**Engineering**	4,877	0.39	95
5	Process	2,721	0.27	111	Study(ies)	2,797	0.22	95
6	New	2,094	0.21	111	Based	2,651	0.21	95
7	Different	1,343	0.13	111	Analysis	2,421	0.19	95
8	Data	1,267	0.13	111	Research	2,336	0.19	95
9	Based	1,204	0.12	111	Used	2,151	0.17	95
10	Used	1,137	0.11	111	Approach(es)	2,007	0.16	95
11	University	968	0.10	110	New	1,680	0.13	95
12	**Understanding**	820	0.08	109	Related	985	0.08	95
13	Figure(s)	1,632	0.16	107	Different	1,792	0.14	94
14	Work(s)	1,410	0.14	107	Use(s)	1,690	0.13	94
15	**Practice(s)**	1,715	0.17	106	**Support**	960	0.08	94
16	Time(s)	1,073	0.11	105	**Model(s)**	4,250	0.34	93
17	**Action(s)**	1,001	0.10	105	Development(s)	2,044	0.16	93
18	Using	816	0.08	105	Case(s)	2,032	0.16	93
19	Approach(es)	1,209	0.12	104	Time(s)	1,872	0.15	93
20	Designer(s)	2,711	0.27	103	Example(s)	1,749	0.14	93
21	Development(s)	1,026	0.10	103	**Specific**	953	0.08	93
22	**Human(s)**	1,012	0.10	103	Data	2,301	0.18	92
23	Example(s)	964	0.10	103	Information	1,893	0.15	92
24	Study(ies)	2,489	0.25	102	**Result(s)**	1,877	0.15	92
25	**Social**	1,169	0.12	102	**Number(s)**	1,658	0.13	92
26	**Way(s)**	1,130	0.11	102	Method(s)	2,383	0.19	91
27	Information	988	0.10	102	Value(s)	2,201	0.17	91
28	**Technology(ies)**	1,049	0.11	101	Work(s)	1,625	0.13	90
29	Case(s)	896	0.09	101	**Problem(s)**	2,104	0.17	89
30	**Making**	752	0.08	100	**Requirement(s)**	1,962	0.16	89
31	**Experience(s)**	2,130	0.21	99	**Level(s)**	1,580	0.13	89
32	Knowledge	1,301	0.13	99	**Table(s)**	1,518	0.12	89
33	**People**	860	0.09	99	**Show(n)**	1,380	0.11	89
34	Method(s)	1,163	0.12	98	**System(s)**	4,156	0.33	87
35	Analysis	878	0.09	98	Knowledge	1,799	0.14	86
36	**User(s)**	2,260	0.23	94	Figure(s)	1,562	0.12	85
37	Value(s)	1,201	0.12	94	**Structure(s)**	1,273	0.10	85
38	Product(s)	15,185	1.53	112	**Quality**	1,156	0.09	84
39	**Interaction(s)**	3,537	0.36	112	**Propose(d)**	1,041	0.08	82
40	**Group(s)**	2,477	0.25	112	**Function(s)**	2,089	0.17	81
	TOTAL	72,733	7.31		TOTAL	102,589	8.13	

Note: Bold words are terms listed only in the top 40 of one of the respective corpora (Design or Engineering Design) and not in the other one.

Similarly, the frequencies of use for the terms support and model in Engineering Design are listed as 0.08% and 0.34%, respectively and the spread for these terms are listed as 94 and 93, respectively.

Tables 1 and **2** compare top-40 lists of Design and Engineering Design with the core academic COCA list. Bold words indicate those that have lower frequency or lower rank compared to the words found in the COCA list. The rate ratio shown in the last column is a distinctiveness metric that is used for keyness analysis [52]. Schützler [53] remarks that comparison of frequencies from different datasets would give the reader some idea of the difference between them but directly measuring and reporting ratios can be more informative. For example, the rate ratio of 49 for the word "process" indicates that this word is 49 times more likely to appear in the design corpus than in the COCA corpus.

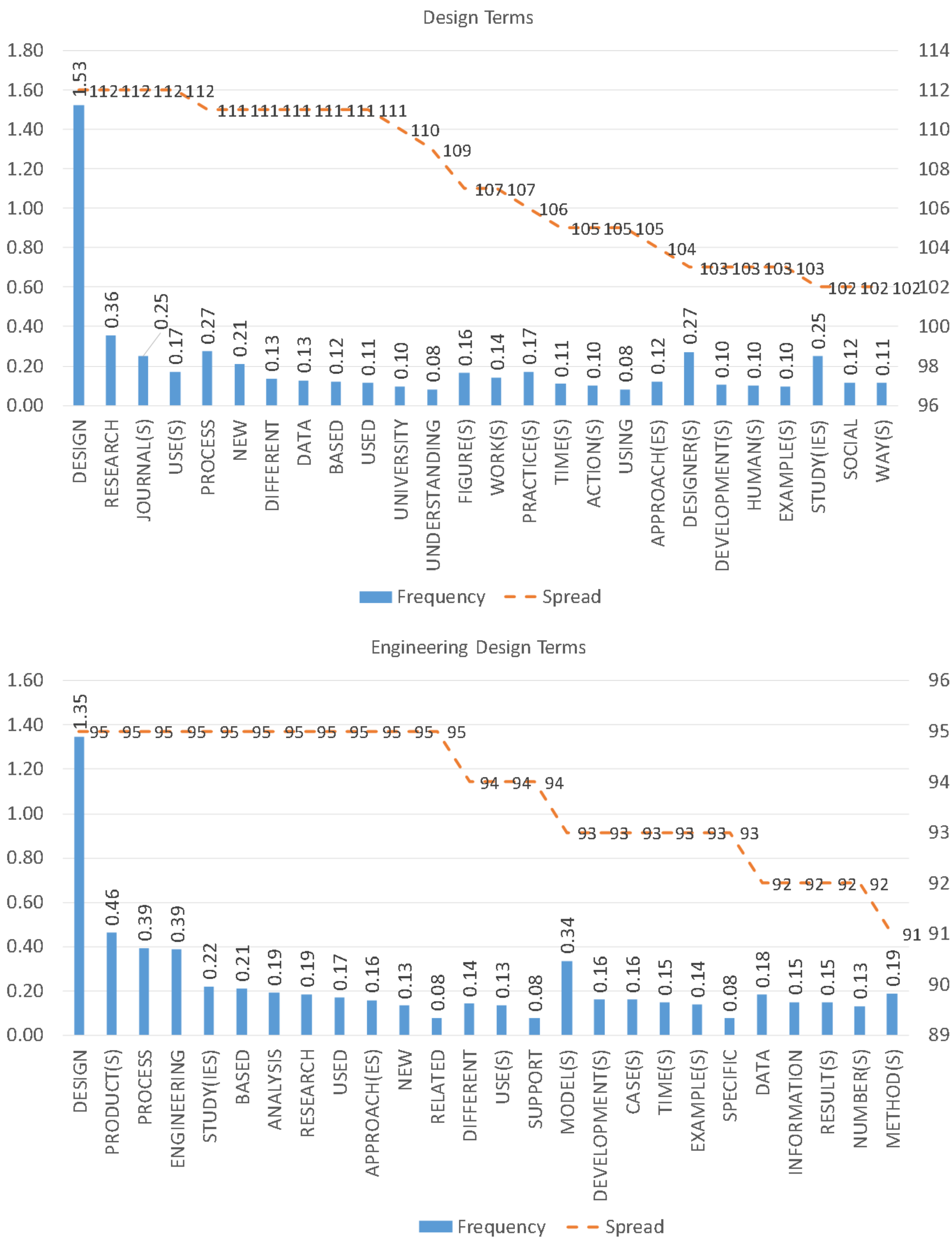

Figure 1. Frequency and spread of the top-25 words in *Design* (top) and *Engineering Design* (bottom) disciplines.

Table 4 shows the frequency of occurrence with regard to paratextual features identified in Design and Engineering Design articles published in 2019 and 2020. Several differences can be immediately noted between these two fields. Probably the most remarkable difference is in the use of formulas. While a total of 553 formulas were used in Engineering Design journals in the given period, not a single formula was used in Design journals. This difference can be attributed to the approach of Design and its communication in the respective fields. While engineering and, in particular, Engineering Design, prefer to communicate information through numbers, symbols, and relationships, i.e., by abstraction, fields of design (industrial design, graphic design, architecture, and others) rely more on visual information and descriptions.

Table 4. Number of paratextual features in Design and Engineering Design articles.

Journal Name/Year Published	Tables	Formulas, Equations	Photographs	Charts, Graphs, Diagrams	Sketches, Drawings, Illustrations	Endnotes	Appendix
The Design Journal							
2019	69	0	49	155	8	19	2
2020	88	0	63	197	10	33	0
International Journal of Design							
2019	39	0	85	167	3	16	5
2020	44	0	49	129	4	8	16
Design Total	240	0	246	648	25	76	23
Journal of Engineering Design							
2019	99	192	11	320	15	48	17
2020	128	60	10	175	18	1	18
Research in Engineering Design							
2019	138	164	10	252	16	0	17
2020	94	137	3	230	15	0	10
Engineering Design Total	459	553	34	977	64	49	62

Tables were more commonly used in Engineering Design: a total of 459 tables, compared to 240 tables in the field of Design. Similarly, the use of charts, graphs, diagrams, and sketches seems to be significantly more frequent in Engineering Design compared to Design.

5. Discussion

5.1. Vocabulary of Specific Disciplines

Detailed analysis of **Table 3** provides more clues about the vocabulary differences between the two disciplines. In the case of Design, the words research and journal are quite common words that can be used in any type of journal article, therefore they are not specific to the field. Interestingly, the term technology appears in the top-40 list in Design rather than in Engineering Design, although it would be expected otherwise, since it is a term interwoven with engineering. This claim might be obvious to engineers but it may need some clarification for the general reader. Technology is defined as "knowledge applied to products or production processes". When discussing the differences between science and technology, Trott[54] points out that "it is engineers and not scientists who make technology happen". The reason that the term technology is frequently used in Design articles may be linked to the growing importance of technology, such as information technology, artificial intelligence, virtual reality, sensors, actuators, robotics, and new materials in various fields of design.

As stated before, contemporary design discourse puts significant emphasis on human needs, social problems, and their solutions, which might explain the high frequency of the keywords human, people, and social, highlighted in **Table 3** and **Figure 1**.

In engineering and science, models are used as representations of a system, phenomenon, or process. Typically, these are mathematical or graphical models (such as 3D models) that might explain the high frequency of Engineering Design articles. In this context, the term support might be used as a mathematical term, such as a "support function". Some collocation examples related to the term model are given below.

It can be interpreted that the words development, study, social, information, and experience (**Table 1**) are not specific to the field of Design since they are also commonly found in other academic publications. Similarly, the words study, research, use, development, data, information, level, table, and system in the Engineering Design list seem to be non-specific words based on this comparison (**Table 2**). Some words such as new and different have no comparative data in the core COCA list which means that their rank is lower than 3,000 on the COCA list. Thus, it can be inferred that words such as new, different, work, time, action, designer, case, making (make), using (use), and people are keywords in the field of Design. In the case of Engineering Design, engineering, new, different, case, time, number, and show appear to be keywords. The context of such words can be understood by some examples of collocation. Note that these examples are not random but purposely selected to demonstrate some of the possible ways that the words are used in a logical relationship with the proper discipline. It is also noteworthy that these examples were found only after two or three iterations in a randomly selected article that was part of the examined database.

Collocation Examples in Design Articles

New:

- ...**new** approaches to design...
- Moreover, evidence points to the failure of 40% of **new** product ventures in the general market.
- This article argues for a **new** breed of digital product designer...
- ...gained insights that led to a **new** type of IoT in the home.
- Although the vast majority of **new** products are incremental innovations...

Different:

- What is good design? Because of its simplicity, research has extensively and endlessly tackled this question from many **different** angles.
- Prototypes can lay particular emphasis on **different** dimensions such as interactivity and functionality.
- A comparison between the results was conducted to explore how images with **different** levels of pictorial richness and semantic depth, with various analogical distance, stimulate design creativity.
- Many researchers and practitioners have argued that designers can bring to light a **different**, possibly more encompassing, understanding of the potentials of a new material.
- ...intended users' needs and expectations in **different** phases of product use.

People:

- Despite the very aim of designing living environments for **people**...
- This artifact was meant to be part of a system of sensors that talk to each other and to human researchers about how older **people** resourcefully arrange and re-arrange groups of objects in the home to complement ageing skills.
- The product combines infrared sensors, microphones, cameras, and other modules for **people** to share their lives with separated relatives...
- Indeed, this event activated connections between **people** and communities committed to defending and developing other, more sustainable ways of living in the city.
- Innovation advances **people**'s wellbeing, ...

Collocation Examples in Engineering Design Articles

Problem:

- This paper outlines an existing method for integrating ontology and engineering, then applies it to a new **problem**...
- ...to maintain design freedom and enhance the design productivity in the early stages of design, and some related works have been employed successfully on various design **problems**...
- However, the connotation of uncertainty for product platform still does not have a unified theoretical explanation, resulting in the following **problems**: (i) how to identify uncertainty, (ii) how to design product platform under uncertainty, ...
- ...it requires detailed a-priori understanding of the design **problem** structure...
- Support vector machine is known for its elegance in solving nonlinear **problems**.

Number:

- In an effort to represent the preference for MARs, fuzzy **number** was used. A fuzzy **number** is a quantity...
- ...the presence of ideas implementing different **numbers** of attributes...
- ...so that R_{ij} is the rank of object **number** j when considering the ranking by expert i.
- The mapping rules that use flows are complex since the function and component differ in terms of the **number** of flows.
- Design process structure: size and density—**number** of domains, **number** of nodes, **number** of edges, **number** of classes, **number** of interfaces between domains, **number** of edges per node, relational density, **number** of unconnected nodes.

Model:

- Balling noted that the traditional optimization-based design process to 'formulate the design problem, obtain analysis **models** and execute an optimization algorithm' leaves designers unsatisfied.
- The protocol studies using the Function-Behavior-Structure **model** to explain the co-evolution of engineering design provide results that suggest that this is critical for smaller, short-duration projects.

- A binary DSM was used to **model** the distributed system architecture...
- ...undertaken through exploring partial structure of design space and solution space, generating some initial ideas in the form of a design concept and bridging these two partial **models** through the articulation of the concept which enables the **models** to be mapped onto each other.
- To achieve these requirements, automotive companies must consider the use of new sustainable **models** that ensure design efforts, customer, and societal needs from product ideation until its end-of-life.

In these examples, it is possible to understand the link between the keyword and the relevant discipline, how it resonates with some other keywords of the same discipline, and the different connotations compared to uses in other fields. Based on the more specific words or keywords that stand out in these lists, it can be argued that the field of Design is more interested in the social and human aspects of products, artifacts, buildings, or the artificial world. On the other hand, the field of Engineering Design deals more with equations, tables, models, numbers, mathematics, and abstraction because it is more interested in functionality, performance, and efficiency. The roots of the two different approaches to design may lie in the epistemologies, traditions, historical development of specific literature, and perpetual repetition of a similar worldview through education, training, and publications.

5.2. Paratext

The reasons for the differences summarized in **Table 4** can be understood by browsing through books on Engineering Design, for example, Pugh [55], Orlov [56], and French [57], as opposed to those on Design or Product Design, such as Norman [58], Papanek [59], and Herriott [60]. It can be noted that the use of mathematics, equations, and technical drawings is common in Engineering Design books, while photographs/sketches of people, products, and their interaction are much more common in books about Design/Product Design. Furthermore, the use of equations and technical drawings is not noted in the latter. Although the term design is common, Engineering Design and Design have very different conventions and approaches to design. Although engineering disciplines aim to pinpoint causal relationships with precise numerical expressions and plot such data for a clearer understanding, design researchers tend to represent their observations through images and photographs, which have the power to tell a story, even if partial or selective. While photography is a common medium used in Design-related publications (246 photographs in 112 articles, i.e., 2.2 per article) it is less so in Engineering Design-related ones (only 34 photographs in 95 articles, i.e., 0.4 per article).

A more detailed analysis revealed that authors who published in Design journals, more frequently expressed themselves with hand sketches and hand-made illustrations (28%), whereas authors who published in Engineering Design journals used hand sketches less frequently (20%) and more computer-aided or computer-generated sketches and drawings (80%). Typically, sketching and free-hand illustration are not common in engineering education but much more so in design education. This is probably the reason for the difference in representation but more detailed analysis is necessary to prove this detail. Endnotes were more frequently used in design articles (26 articles) compared to engineering design articles (7 articles). This may be related to the conventions of the related disciplines and journals.

6. Limitations and Recommendations for Future Work

One of the weak points of the method used herein is that each time the corpus changes, the frequency and spread also change. It can be foreseen that using a much larger corpus would increase the reliability of the analysis and provide statistically more significant links between each discipline and the distinctive terms. Similarly, the results would probably change in time due to changes in technical or domain-specific terms. However, the present analysis based on the selected corpus is relevant and provides useful indications for further research and discussions. The study was limited to two years due to the capacity of the available software and some manual tasks that needed to be used in the process. Analysis with a larger corpus and using automated algorithms can improve the reliability of the present approach. Paratextual analysis relied on manual counting, making it difficult to apply to larger corpora. For very large corpora, the use of specifically written computer programs or the use of AI would be recommended.

Suggested future work may include interviews with professionals and academicians active in the fields of engineering design and various design disciplines using English during daily practice in order to determine keywords that are believed to be specific to their field. Another direction could be to use a similar methodology presented in this article but use different sources such as books, videos, conference proceedings, and reports, to name a few. Temporal analysis within comparable publications would be valuable to understand how keywords and terminology changed throughout the decades in each discipline.

7. Conclusions

Although Engineering Design and Design have many common grounds, some important differences were pinpointed in terms of vocabulary and paratextual features of representative articles as follows:

- Quantitative vocabulary assessment of the Design corpus and comparison with the core academic COCA corpus indicated that words including new, different, work, time, action, designer, way, using, making, and people appear to be specific to the field of Design.
- Similarly, frequently used and specific terms in the selected Engineering Design articles were assessed to be engineering, new, different, time, number, work, problem, and show, among others.
- Comparison of the most frequent 40 words derived from the Design and Engineering Design corpora indicates that the use of words understanding, practice, action, interaction, experience, human, social, user, technology, and people are more common in Design articles, whereas the use of words engineering, support, model, specific, result, number, problem, requirement, level, system, structure, quality, function are much more common in Engineering Design articles.
- Contextual analysis of some of these words better explains the context and connotation of these words.
- Paratextual analysis indicated that the use of equations is very popular in Engineering Design articles, whereas they are not used in Design articles. The use of photographs is significantly more frequent (~7-fold) in Design articles compared to Engineering Design articles, whereas the use of charts, graphs, and diagrams is more common in Engineering Design articles, in contrast to Design articles. The use of tables is also more common (about twice as much) in Engineering Design compared to Design.

The significant differences between the fields of Engineering Design and Design in terms of vocabulary and paratext seem to be associated with their respective origins and different epistemologies. While Engineering Design originated from fields of engineering, which uses a positivist approach in research, the Design discipline originated from social sciences and art, which use post-positivist and social epistemologies. Although the details of epistemological differences between the two fields are beyond the scope of the present study, such a theoretical study would be an important contribution to both the design and linguistics literature.

Several practical applications can be foreseen regarding the results of this study. In design education, a discussion on the preference of certain keywords within different disciplines could be useful in various courses, particularly the ones that require writing reports, essays, or research papers at both undergraduate and graduate levels. Understanding the preference and context of such discipline-based vocabulary is essential in academic writing. The results would also be valuable during the preparation of teaching materials for English for Academic Purposes (EAP) courses.

Proper selection of keywords is crucial during the preparation of an article in order to increase the visibility and the potential of being cited. Text mining, text-based Internet search, computational semantics, and artificial intelligence tools that are rapidly evolving, require the selection of the most appropriate keywords for the best results. The proper use of keywords is crucial both during the development of new software and tools, as well as during their use by students, academicians, researchers, and practitioners. Furthermore, the list of discipline-specific terms could contribute to the enrichment of dictionaries, lexicons, and discourse of design and design engineering.

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Conflicts of Interest

The author declares no conflict of interest.

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