

Spanish academic writing for aerospace engineering students

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Abstract: In the contemporary landscape of international academic communication and research, it is essential to consider how to instruct both undergraduate and graduate aerospace engineering students learning Spanish as a second language in the art of writing research papers. The paper deals with the analysis of aerospace technical texts' structure and design in Spanish. The research base consists of original open-access papers on aerospace engineering published from 2018 to 2024. Since there is a clear lack of such teaching materials in the Spanish language, the issue is of significant relevance. The purpose of this paper is to analyze the structure of aerospace technical texts, to reveal the sequence of scientific knowledge presentation and its corresponding connectors, and to provide practical recommendations for undergraduate and graduate students. The findings suggest that: (1) the structural units of the text reflect the stages of the researcher's cognitive activity; (2) an aerospace technical text is a logical chain of the author's ideas, based on previous knowledge and cognitively related to their findings, with an outlook for future research; and (3) each text unit, understood as a structural element, has specific connectors within the text. This paper identifies text structural units designed to construct a comprehensive model of the aerospace technical text and provides appropriate Spanish connectors for each. The primary research methods employed include a structural analysis approach and a descriptive method, utilizing techniques such as observation, interpretation, and generalization. The findings offer practical solutions to improve engineering students' academic writing, which can be applied to teaching processes or to enhance current instructional approaches.

Keywords: *Spanish aerospace technical text, Teaching for academic purposes, Text structural units.*

1. Introduction

Academic writing has various spheres of actualization: besides scientific dialogue between specialists, we are interested in giving some general guidelines that make the construction of an academic text on aerospace engineering available to undergraduate and graduate L2 Spanish students of aerospace engineering. Academic writing is a prose style, usually presented in an impersonal and dispassionate tone, it targets a critical and informed audience based on well-grounded and proven knowledge; and aims to reinforce or challenge concepts or arguments [1]. A research paper is a form of academic writing that thoroughly illuminates any subject, conducts analysis, and provides evidence in a highly organized and structured way. UNESCO has stated that the essential purpose of a research paper is to communicate the results of study and debates in a clear, concise, and reliable manner [2].

The objective of this paper is to examine the structure of aerospace technical texts to uncover the sequence in which scientific knowledge is presented and the corresponding connectors that contribute to the logical coherence and organization of the text. Additionally, it seeks to establish guidelines for the preparation of research papers and to provide practical recommendations for both undergraduate and graduate students learning Spanish as a second language.

It is obvious that a scientific text is not an autonomous element, but it is made up of elements from other texts that are marked, to some extent. Texts are inherently intertextual: they incorporate elements from other texts for a specific purpose. Every text is connected to a universe of texts that come

from it [3]. The way in which prior texts are incorporated into a new text is complex. A text can mix several prior texts, assimilate the prior text, comment on it, substitute it, contradict it, respond to what is said in it, reemphasize it [4].

Currently, in most cases, the text is seen as a particular aspect of a broader phenomenon that is discourse and is studied by the discipline called “discursive analysis” [5]. Academic discourse is the result of a special kind of dialogic interaction, combining elements of scientific argument and informative dialogue, the participants of which are either real scientists, or scientific texts, in which the thoughts and ideas of the participants are implemented.

The structure of an academic paper is examined by analyzing the typical content found within its structural units, which function as communicative and pragmatic text units. A research paper should be structured effectively, clearly outlining the key steps involved in the learning process, while maintaining a logical flow and incorporating elements of scientific prediction. Contemporary understandings of academic text composition and semantic organization define these units as stable, representative text structures which form the ideal model of academic writing [6]. The relationship between the units is established not primarily through surface-level textual features, but rather through a deeper, semantic coherence that binds them together as a whole.

As V. Chernyavskaya stresses, a communicative pragmatic unit of an academic text is a structural-semantic text unit, which is the result of the linguistic materialization of one or several communicative-cognitive actions, functioning as a structural element of content, characterized by a communicative focus on the expression of the scientific knowledge relevant to the author and realizing the function of influence [4].

We propose to define aerospace academic discourse as a higher communicative unit that is subject to a communicative intention determined in the conditions of specialized communication in aerospace studies and has the structural and conceptual organization, functional orientation in accordance with the corresponding pragmatic intention. The nature of the aerospace academic discourse is the research of world's leading experts in aerospace engineering based on dialogic interaction, that contains issues of scientific argument and informative dialogue. The participants of the dialogue are scientists or scientific texts, representing a written form of academic discourse, which embody scientists' thoughts and ideas.

The conceptual structure of the research paper represents a complex unit that is made up of two types of content: the informative communicative content and the pragmatic content. The informative communicative content is correlated with an explicit textual structure of scientific knowledge that reflects the stages of the researcher's cognitive activity and establishes the relationship between the subject of knowledge and the object of knowledge. The pragmatic content represents a kind of packaging of the informative communicative content and forms the pragmatic orientation of the full text.

2. Methodology

Source language material are research papers devoted to studying aerospace science problems, collected in SCielo, Dialnet, and Journal “Ingeniería Investigación y Tecnología” with total number of pages of 650. Research methods are determined by the specific goals and objectives of the study. The primary methods employed in this research include structural analysis and a descriptive approach, utilizing techniques such as observation, comparison, interpretation, and generalization. The main methodological approach of this research is the interpretation of the academic discourse considering its structural components:

- Constitution of the general corpus of academic discourses;
- Selection of the pragmatic aspects of academic aerospace discourse;
- Identification of the verbal connectors of academic aerospace discourse;
- Modeling of the structure of academic aerospace text.

The analysis is based on the cognitive activity of the subject who investigates the scientific object of the study. Academic aerospace discourse is defined as a superior communicative unit that is subjected to a determined communicative intention in the conditions of specialized communication and has the structural-conceptual organization and functional orientation according to the corresponding pragmatic intention. Academic discourse characterizes the communicative process leading to the formation of a certain formal structure that is the scientific text. The authors examine the conceptual framework of aerospace academic papers and identify fundamental communicative structural units that facilitate a coherent and systematic development of the academic discourse.

The discursive and communicative approaches comprise the methodological base of the research. Any discourse should be understood as texts in close connection with the situational context: in conjunction with the social, cultural, historical, ideological, psychological, and other factors, with the system of communicative-pragmatic and cognitive target settings of author that interacts with the target determination of a specific ordering of linguistic units at implementing within the text. Each stage of work involved the methods that best meet the goals and objectives of research: a method of structural analysis and a descriptive method with the use of such techniques as observation, interpretation, and generalization.

3. Analysis and Discussion

3.1. Research Paper Structure

In the analysed aerospace technical texts stand out such text structural units as: “Title”, “Abstract”, “Keywords”, “List of acronyms/Nomenclature” (optional), “Introduction”, “Literature Review” / “Historical and Theoretical Framework”, “Problem Statement”, “Hypothesis”, “Methodology”, “Study Phases”, “Results and Discussion”, “Conclusions and Future Work”, “Acknowledgements” (optional), and “References” / “Bibliography”.

When exploring the structure of an aerospace technical text, it is worth noting that such text structural units as “Title”, “Abstract”, “Keywords”, “List of acronyms/Nomenclature”, “Acknowledgements”, and “References” / “Bibliography” are of a subordinate nature regarding to the primary scientific text which contains the following structural units: “Introduction”, “Literature Review” / “Historical and Theoretical Framework”, “Problem Statement”, “Hypothesis”, “Methodology”, “Study Phases”, “Results and Discussion”, “Conclusions and Future Work”.

The title of a research paper should inform about its content clearly and precisely, allowing the reader to easily identify the topic. An abstract accompanied by keywords is a short summary of the research paper, which serves the following purposes: to communicate the relevance of the research, methods, and key findings. It quickly gets the essence of the study, so the addressee can decide whether to read the full paper. It should normally be between 150 and 200 words, written in a single paragraph in Spanish and translated into English.

After keywords the fundamental definitions used in the research paper may be optionally described in the part “List of acronyms”/ “Nomenclature”. Nomenclature entries are listed alphabetically (capital letters before lowercase), in the following order: regular letters, Greek letters, numerals, and special symbols. Units of measure should be included in definitions where appropriate. For example:

- F = Restoring force
- f = Elastic displacement
- d = Wire diameter
- G = Crosswise slip modulus
- Dm = Mean loop diameter
- n = Number of turns
- C.I.R. = Instant center of rotation
- h = Height of the gravity centre
- l = Distance between the rear and front axles, etc.
- α = Angle of attack

β : = Flap deflection angle

μ_{∞} = Freestream density

In “Introduction” the researchers justify the reasons why the research is carried out and formulate the hypotheses and relevant objectives, highlight the previous studies, and locate the research topic within the discipline of investigation.

The units “Literature Review” and “Historical and Theoretical Framework” can either be included in the “Introduction” or form their own sections. “Historical Framework” involves retrospective analysis of the topic and locates at what stage of development lies the problem under investigation. “Theoretical Framework” is one of the core parts of the investigation since it determines the theoretical base of the research.

The unit “Methodology” details the way the research was performed: the methods and strategies that contributed to the research.

The unit “Results and Discussion” sets out the data that was collected, discusses the results of the tests that were performed, and puts the findings in context.

The “Conclusions and Future Work” should be in accordance with the research objectives, restates the problem statement avoiding phrasing it identically to how it appeared in the “Introduction”, summarizes the overall findings, suggests the key takeaways from the study, describes how the obtained results address the topic under investigation, and determines future research directions.

3.2. Cognitive Parameters and Verbal Connectors of the Text Structural Units

The progression of a scientific text mirrors the evolution of the researcher’s cognitive process. Concurrently, the progression of the knowledge presented in the text from hypothetical to more justified is conducted according to the principle of its content-thematic openness to a broad range of special scientific information. Actually, new knowledge of the researcher becomes scientific only on condition of its registration in the system of the available knowledge.

Each scientific text marks a transition from prior knowledge to new knowledge. It is necessarily correlated with many previous texts as a theoretical foundation for newly created scientific research and is prospectively oriented towards future investigations. Novelty in science appears as an integrative unity of new and prior knowledge. The interweaving of the known and new permeates the whole process of a scientific text deployment and acts in it as one of the textual formation mechanisms.

As we have already stated, the conceptual structure of the scientific text represents a complex unit that is made up of two types of content: the informative communicative content and the pragmatic content of the text. The content of scientific knowledge forms the cognitive core of the researcher’s conception of the scientific framework. This core includes two important components of the continuous sequence of science, that is, the new knowledge provided in the research and the prior knowledge in their dialectical link. Each structural unit has its special markers and connectors on the textual surface.

Let us look at the text structural units understood as structural-semantic textual units, and verbalization of cognitive concepts to carry out their intentional functions.

The structural unit titled “Introduction” assesses the relevance of the research topic and the degree of its novelty in the context of scientific continuity. The “Literature Review” / “Historical and Theoretical Framework”, “Problem Statement”, and “Hypothesis” are tightly bound, being the epitome of the principle of the prior and new knowledge unity. For example,

“Vertical and horizontal axis wind turbine *designs have been proposed, such as those developed by Chávez [7]; Hernández, et al. [8]; García, et al. [9]; Mendoza [10] and Chimal and Palomares [11]. However, specific designs of wind turbines for a particular region are not made. The aim of this work is to design the rotor of a vertical axis type Phi wind turbine.*” [12].

The various forms of textual representation of prior knowledge are determined by their cognitive and communicative functions. These functions encompass appealing to authoritative views to support a new stance, identifying gaps by analyzing existing knowledge, developing a new concept grounded in

existing knowledge, and analyzing previously employed principles, methods, and approaches to identify the most effective strategies to solve a given issue. For example,

“For the design of vertical take-off VANT, the interactions between propellers in push configuration and vertical rotors were studied, *obtaining the necessary data to improve the performance of the aircraft.*” [13].

Such lexical items as: *numerous authors, previous studies, this type of problems has been widely studied in*, demonstrate the idea of scientific knowledge accumulating and consolidating in a certain intellectual field. There is also a correlation of individual studies in the general system of knowledge.

The use of the textual fragments of other authors has its own pragmatic in scientific communication, since it not only allows the virtual dialogue to be formed, but also involves the opinions and points of view conventionally adopted and approved by the scientific society.

A primary method of conveying prior knowledge involves reproducing the discourse of other scientists through quoting, paraphrasing, and employing both direct and indirect speech. The verbal operators that facilitate the integration of this prior knowledge function are verbs related to speech and thought, indicating the necessity of acknowledging someone else's statement within their context: *according to a scientist, as stated by, as claimed by, in the opinion of, in conformity with, etc.* For instance,

“The terms control surfaces, control and flap are used interchangeably in this work, since, *according to Perkins and Hage* [14] control surfaces are generally a simple flap located at the rear of a profile. Raymer [15] *considers* the reduction of skin drag as an advantage, as the aircraft encounters clean airflow” [16].

The new knowledge, verbalized in the text plane, is a speech structure that represents the subject content of the acquired knowledge. Upper boundary of new knowledge can be considered as formulation of the problem and the purpose of research, which is usually expressed by direct nomination: “*The goal of the research is to gain a better grasp of fluid dynamics phenomena.*”

The author, according to the tasks presented in the research, uses different discursive strategies, that is, introduces the addressee into the common knowledge system, giving determination of the key research concepts, definition of the research objectives and explanations of the necessary causes of the investigation:

- states the problem: “Disturbances in the electrical system without any kind of regulation *present different anomalies...<>. This research incorporates a new solution* through the automation of the elements.” [17].
- defines the key concepts and their logic-semantic relationships: “*The results obtained in this study can be used for the experimental validation of complex computational fluid dynamics models.*” [19].

The typical verbal resources for the pragmatic unit “Problem Statement” are the following discursive constructions:

This study focuses on; The objective is to establish the causes; The research seeks to investigate; It is of interest to establish; This project aims to develop; The research intends to; The study provides contributions to; The research paper attempts to determine, etc.

In scientific research, the hypothesis is a tentative proposition that is formulated to explain a phenomenon or answer a research question. It is an assumption, based on prior knowledge, which is tested to determine its validity. The hypothesis acts as a guide for research, helping to focus efforts and select the most appropriate methods to obtain results. The typical verbal resources for the unit “Hypothesis” are a direct nomination or impersonal discursive constructions with the hypothetical modality:

The working hypothesis of the project is that; The hypotheses that arise; It can be assumed; It is to be expected; It is assumed; Possibly; It is proposed; This allows us to propose (assume, determine, consider), etc. For example,

“*The hypotheses of the model adopted in this study are presented below. It is proposed* that the material is part of a two-stage rocket, which will be subjected to both thermal loading due to launch and axial loading” [12].

In academic research, methodology pertains to the array of methods, techniques, and procedures employed to conduct a scientific inquiry, encompassing everything from problem setting to result presentation. It serves as a vital tool within the research domain, systematically addressing the fundamental components that guide a project in a methodical way.

The typical verbal connectors for the unit titled “Methodology” in aerospace technical texts are as follows:

The methodology is based on; For the development of this study, the following methodology was employed; The methodology has been supported by (the use of the program); The type of method used to carry out the study is; The method is applied; The data analysis has been used; The theorem was applied to estimate; Using the equation, we obtain; Diagrams are used for calculation; The methodology proposed here seeks to develop a model; Graphs have been created to estimate, etc. For example,

“For the development of this study, the software Qblade [18, 19] was used, which is free to use and was developed by the wind energy group of the Technical University of Berlin.” [20].

“The Posicast controller design methodology is based on separating the reference signal into two sections” [21].

The unit “Methodology” includes “Study Phases”, and describes how the research will be carried out, including the design of the experiment, the materials used and the methods applied to collect and analyse data:

The first step is, the next step is to obtain, with the obtained values the modelling is built, the study comprises three stages, in the first stage the protocol was carried out, the second stage consisted of, in the third stage it was calculated, etc.

The unit titled “Results and Discussion” outlines the findings and provides an interpretation of their implications. This section presents the discovered outcomes in an objective manner, while the discussion interprets these results, situates them within a broader context, and elucidates their significance. The verbal connectors used in the text unit “Results and Discussion” are as follows:

The results were obtained using; It should be noted that; The results, as exhibited in Figure 25, show that; It can be deduced that; It is observed that; The results based on close observation; One can observe that; The collected data prove; To summarize the findings; To consider (compare, interpret) the results; On the one hand,...on the other hand; As indicated (shown) in; As the chart shows; Table 1 demonstrates; The diagram displays (illustrates, shows); The figure depicts, etc. For example,

“When comparing the results of Figures 9, 10, and 11 with those of Figure 12, it can be observed that the changes δx and δy in the trajectory relative to the nominal are more sensitive to changes in β_{81} than to changes in β_{15} , β_{18} , and β_{11} ” [12].

The foundational aspect of newly acquired knowledge is the formulation of a conclusion in the unit “Conclusions” which, from a linguistic perspective, is articulated as a generalized statement that logically follows from prior reasoning. It is a clear and objective presentation of the study findings.

The usual verbal elements found in the text unit “Conclusions and Future Work” pertain to cognitive communicative actions such as summarizing the principal ideas of the research and emphasizing the significance of the findings to the reader. This section encapsulates the most crucial discoveries and their relevance, highlighting the contributions made by the study. The primary role of the conclusions is to provide a logical closure to the set problem:

We draw (make, reach) the following conclusions; The result of this study indicates; These results allow consider; The following conclusions can be reached; It is convenient to point out the following conclusions; In conclusion; The main conclusions are; The obtained findings prove; The reported results indicate; Based on the results it can be concluded; It confirms (supports, verifies) the hypothesis, etc.

According to our observations the text unit “Conclusions” does not have such a modal dominant as categorical judgments in spite of the highly concentrated new information. This is in accordance with the notion of an ‘open end’ for scientific research and its potential appeal to future developments. Further continuity of scientific knowledge in this unit is achieved through such verbal constructions as:

The subsequent project will carry out similar research; To be considered within the future of aerospace technology; For the case a more comprehensive study will be carried out, etc. For example,

“Future study based on this research will include structural analysis of parts and materials, selection of an electric generator and power conditioning circuit, and an assessment of system efficiency, as well as a cost-benefit analysis for feasibility.” [22].

In contrast to the previously discussed primary scientific text units, the unit titled “Acknowledgements” lacks a formative textual role and does not connect to the author's overarching concept. The common verbal identifiers for this unit are listed below:

The authors would like to acknowledge; The authors are grateful for; The authors would like to extend sincere gratitude; The author would like to thank, etc.

The incorporation of the above-mentioned unit within the text is fundamentally an issue of scientific ethics, serving as a standardized and formalized entity.

When writing a scientific paper, as we have already mentioned, numerous authoritative sources are used. All of them should be mentioned in the study. The list of used literature is drawn up at the end of the research paper in the unit “References” / “Bibliography” in accordance with such citation styles as IEEE citation style, AIAA citation style, ASME citation style, etc. at the request of the editorial office of the journal.

4. Practical Recommendations

Writing a research paper requires the author both the ability to collect and process information, as well as properly express his/her thoughts. One of the mandatory requirements when writing articles is adherence to scientific style, as well as having a clear structure and content of the project. Following the structure of the scientific article, described in the main part of this study, and the sequence of stages of the author's conceptual activity provides a neat composition of the scientific text. When it comes to engineering students learning Spanish, it is important to follow general recommendations and to take into account the specific guidelines tailored to this context. The following stages of developing a research are proposed:

1. *Theoretical and Exploratory Stage.* During this stage, the researchers should study the state of scientific knowledge on the issue in Spanish and in their native language. This stage includes the definition of the topic of the article, which anticipates its structural-compositional features. There is an accumulation of material on the topic.

2. *Researching the terminology Stage.* Researchers are highly recommended to *compile a glossary of terminology*, providing its grammatical features, definitions and translation, as the one below (Table 1.):

Table 1.
Example of Aerospace Terminology Glossary.

Term in Spanish	Definition	Translation
Cohete (Masculine noun)	Aircraft that moves in space by jet propulsion and is used for military or scientific purposes [23].	Rocket (n)

The compilation of such a glossary is extremely important, because the use of uniform terminology and its accuracy in future published research is crucial.

It is suggested *to create terminology cards*, along with the glossary, to enable more comprehensive work with the terms that are presented in context, as following:

Table 2.

Example of the Terminology Card for the Term Aerogenerador de eje vertical.

Issue:	Aerospace
Topic:	Aerospace technology
Term:	A vertical-axis wind turbine
Term in context:	The aim is to obtain the appropriate configuration parameters for the subsequent design of a vertical-axis wind turbine of similar dimensions.
Abbreviations for the term, if there are any:	VAWT
Source text:	https://doi.org/10.22201/fi.25940732e.2024.25.4.028

3. *Modelling Stage*: At this stage, students acquire an understanding of the Spanish technical texts' structure, including their text structural units, while also establishing the objectives and the hypothesis of their studies.

4. *Practical Stage*: Start writing the work following the structure described in this paper and using verbal connectors proper for each text structural unit.

When considering the model of writing a research paper it is necessary to outline such basic principles as: interaction and feedback, visual representation of strategies to construct a research paper. The research supervisor provides interaction and feedback, combining the responsibilities of teacher and adviser, offers contact and feedback, putting forward guiding concepts, and encourages students' curiosity and self-assurance.

5. Conclusions

This study examined the structural organization of aerospace technical texts, uncovering the sequence in which scientific knowledge is presented, and providing the connecting elements that ensure logical text coherence. The findings offer practical guidance for both undergraduate and graduate students learning Spanish as a second language.

The results indicate that the informative content is linked to a clear textual structure of scientific knowledge, which mirrors the phases of the researcher's cognitive process. An aerospace technical text represents a coherent sequence of the author's thoughts, grounded in prior knowledge and cognitively associated with new discoveries, while also considering future research directions.

The practical recommendations provided in the study can be beneficial for engineering students.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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