UNIVERSITY GENRES AND MULTISEMIOTIC FEATURES: ACCESSING SPECIALIZED KNOWLEDGE THROUGH DISCIPLINARITY

GÊNEROS UNIVERSITÁRIOS E TRAÇOS MULTISSEMIÓTICOS: ACESSANDO O CONHECIMENTO ESPECIALIZADO ATRAVÉS DAS DISCIPLINAS

GÉNEROS UNIVERSITARIOS Y RASGOS MULTISEMIÓTICOS: ACCEDIENDO AL CONOCIMIENTO ESPECIALIZADO A TRAVÉS DE LAS DISCIPLINAS

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RESUMO: Nesse artigo é feita uma descrição preliminar do Corpus Acadêmico PUCV-2010, na qual é apresentada uma abordagem dos materiais de leitura de estudantes de doutorado em Química, Biotecnologia, Física, Lingüística, Literatura e História (3160 textos). O corpus foi coletado em 12 cursos de doutorado em seis universidades chilenas e compreende todos os documentos dados aos estudantes para leitura durante seu curso, com excepção dos incluídos na fase da pesquisa final de doutorado. Na análise dos 33% do corpus (1043 textos), nove artefatos multissemióticos foram identificados, sendo realizada e uma quantificação da ocorrência desses artefatos em todas as disciplinas. Distinções interessantes surgiram, com base na análise de como significados são construídos nos textos das seis disciplinas. Os principais resultados empíricos revelam diferenças: a) no número de textos que circulam em cada da disciplina e campo de conhecimento (ciências mais empíricas versus ciências mais teóricas), b) na língua dominante nos materiais de leitura (inglês e espanhol), c) na relação entre disciplina e artefatos multissemióticos, d) na predominância do sistema verbal nos textos das ciências sociais e humanidades e dos sistemas matemático, gráfico e tipográfico nos textos das ciências básicas.
PALAVRAS-CHAVE: artefatos multissemióticos; disciplinas; gêneros escritos.

RESUMEN: En ese artículo es hecha una descripción preliminar del Corpus Acadêmico PUCV-2010, en el cual es presentado un abordaje de los materiales de lectura de estudiantes de doctorado en Química, Biotecnología, Física, Lingüística, Literatura e Historia (3160 textos). El corpus fue colectado en 12 cursos de doctorado en seis universidades chilenas y comprende todos los documentos dados a los estudiantes para lectura durante su curso, con excepción de los incluidos en la fase final de investigación del doctorado. El análisis de los 33% del corpus (1043 textos), nueve artefactos multisemióticos fueran identificados, siendo realizada y una cuantificación de la ocurrencia de esos artefactos en todas las asignaturas. Distinciones interesantes surgieran, con base en el análisis de cómo significados son construidos en los textos de las seis asignaturas. Los principales resultados empíricos revelan diferencias: a) en el número de textos que circulan en cada asignatura y campo de conocimiento (ciencias más empíricas versus ciencias más teóricas), b) en la lengua dominante en los materiales de lectura (inglés y español), c) en la relación entre asignatura y artefactos multisemióticos, d) en la predominancia del sistema verbal en los textos de las ciencias sociales y humanidades y de los sistemas matemático, gráfico y tipográfico en los textos de las ciencias básicas.
PALABRAS-CLAVE: artefactos multisemióticos, asignaturas, géneros escritos.

ABSTRACT: In this article a preliminary description of the Academic PUCV-2010 Corpus is given, in which an account of the reading materials of doctoral students in Biotechnology, Chemistry, Physics, Linguistics, Literature, and History (3,160 texts) is presented. The corpus was collected in twelve PhD programs in six Chilean universities and comprises all the documents students were given to read during their formal curricula, with the exception of those included in the final doctoral research. In the analysis of the 33% of the corpus (1,043 texts), nine multisemiotic artifacts were identified and a quantification of their occurrence across disciplines was determined. Interesting distinctions emerged, based on how in the texts from the six disciplines meanings are constructed. The main empirical findings reveal differences in: a) the number of circulating texts in each discipline and knowledge domain (more empirical sciences versus more theoretical sciences), b) the dominating language in the reading materials (English and Spanish), c) the relationship between discipline and multisemiotic artifacts, c) the predominance of verbal system in Social Sciences and Humanities texts over the mathematic, graphic and typographic in Basic Sciences texts.
KEYWORDS: multisemiotic artifacts; disciplines; written genres.

1 INTRODUCTION

Research on multisemiotic descriptions of written academic texts has been scarce. Not many investigations focus, from a corpus-based perspective, on the study of the interaction between the verbal system and illustrations, formulae, or tables, as well as their layouts, as part of academic reading materials. Consequently, the inherent multisemiosis of written specialized texts has not been yet fully addressed

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(PARODI, 2010a). As well known, the verbal or linguistic system has been given predominantly studied, possibly because the concept of language has been dominated by immanentist approaches and because the study of the verbal system in itself presents tremendous challenges that have still not been completely investigated.

Our own studies have concentrated on the analysis of the *stricto sensu* linguistic system, though from a multidimensional and functional rhetorical perspective (PARODI, 2005, 2007a and b, 2010b and c). Research on the PUCV-2003 Corpus as well as on the PUCV-2006 Academic Corpus have primarily addressed the verbal system and have only somewhat dealt with nonverbal features. This is probably due to the effort involved in developing a tagger and parser for Spanish, along with a wide and robust database that allows for online consultation, as in the El Grial project (www.elgrial.cl) (PARODI, 2006, 2010b).

In this context, the objective of the present study is to identify and describe the (multi)semiotic artifacts of the academic discourse in six disciplines of the PUCV-2010 Academic Corpus. We will also compare the frequency of occurrence of these artifacts in the texts across the six disciplines, exploring certain variables such as average frequency per page. In this first approach to the corpus data, we are emphasizing a disciplinary perspective of the written academic discourse that students in six doctoral programs must read during their university education. Thus, in this phase of the research we are not making distinctions between discourse genres, given that the focus is on the study of the disciplinary academic discourse and its characterization based on the multisemiotic artifacts identified in a random sample of 33% the total corpus. This study focuses on the interface among four semiotic systems in the written texts: the verbal, graphic, mathematical and typographic.

In the first part of this article, we will review some conceptualizations on multisemiosis and its fundamental role in the constitution of written texts. Then, we will discuss the corpus and the collection procedures, followed by laying out the methodological steps and presenting the findings. Finally, some final remarks and projections will be given.

2 MULTISEMIOSIS: A BRIEF OVERVIEW

2.1 Verbal/nonverbal distinction and paratext

The distinction between verbal and nonverbal systems has been classically accepted, thus also using the term *language* to refer to such things as body language and the visual realm in general. In the case of spoken language, these extra-linguistic resources were the first to be given attention, leading to talking about communication via touch, body posture, smell, etc. In a seminal book, Davis (1976) pointed out that interest in nonverbal communication comes out of a tendency to distrust words, as we would be more visually inclined, "more open to visible communication, body language" (DAVIS, 1976, p. 252). Along with this text there are two others, one written by Poyatos (1983) and the other edited by him (POYATOS, 1992). In these books the relationships between the verbal and nonverbal languages are explored in areas such as literature, linguistics, sociology, anthropology, etc. The objectives laid out in this last book are: to include areas not previously addressed, to motivate research in minimally or not at all explored areas and to achieve higher recognition for nonverbal communication studies.

In the case of written texts, paratext has been traditionally and etymologically defined as everything that surrounds or accompanies the text or everything that is left in a book or publication when the main text is taken out. Alvarado (1994), following Genette (1997), proposed three dimensions to paratext: verbal, iconic and material. The classifications are generally based on the point of view of the writer, distinguishing between the author, editor, designer, etc. Thus, the analysis of the concept of paratext is directly linked to the authorship of the sections. In sum, paratext is limited to certain sections of the text, typographic

variations and the layout of the text, as well as the graphics on the page. All these elements, be they verbal, iconic or infographic, are the majority of the time considered to have an auxiliary function rather than fundamental, as –from this perspective– the text itself in its essentially verbal nature is the nucleus.

Focusing on the distinction and separation between text and paratext, we believe there is an emerging confusion regarding the concept of text itself and the decision, in fact not always evident, of whether other semiotic systems are inherent parts of all texts or if they are secondary to the text itself (mainly considered as being purely verbal). Given this perspective, it is clear that, in general terms, these studies have established a distinction and have separated the verbal system from other possible systems. The nonverbal is valued, but it is not considered inherent to the text itself and a certain sense of ambiguity in the multisemiotic nature of texts is detected.

2.2 The discovery of the obvious: The multisemiosis of written texts

Notwithstanding the points commented on above, we agree with Scollon and Scollon (2009) on that the multisemiosis of the written text is not just a new way of looking at an area classically termed "nonverbal". It is much more than that.

In this section, we are not attempting to review all the current studies on the multisemiosis of written texts. Our objective is to establish a basic conceptual framework in which our research is based on. We start from the fundamental principle that all written texts are essentially of a multisemiotic nature. From this perspective, the issue is not deciding whether a written text is multisemiotic or not, but rather determining how many semiotic systems are considered in the "multi" and what is a "system". These are fundamental questions in addressing this relatively new field in the scientific investigation of written texts.

More recently, in the linguistic area, this topic was brought up by the works of Kress and van Leeuwen (1992, 1996, 2001), although with a term that has been widely disseminated: multimodality. Studying the nature of genres and disciplinary discourse has shown the need to study multisemiosis as an inherent characteristic of texts, thus overcoming the more exclusively linguistic outlook on textual typologies. Along with this, the research on texts in general, the interest in printed media and advertising, and the emerging web genres have also drawn attention to multisemiotic artifacts (VENTOLA; CHARLES; KALTENBACHER, 2004; ROYCE; BOUCHER, 2007; MARTIN; ROSE, 2008; JEWITT, 2009).

Lemke (1998), very accurately in our opinion, states that meaning cannot be constructed through just one semiotic system. Phylogenetically, human communication has progressively developed into the use of multiple semiotic systems, creating increasingly more complex and complete discourses that allow for the construction of advanced knowledge, such as its transmission and access though various genres. In fact, it was Lemke (2005) who said that genres, in certain contemporaneous contexts, could become diluted and hybridized very flexibly, becoming constructions that no longer move institutionally, but rather thematically.

As O'Halloran (2005) points out, likely due to the new nature of the field, there is still no widely agreement upon terminology within the disciplinary community, which has led to some confusion and lack of precision. Perhaps the most serious is the confusion between the terms *mode* and *modality*, both with the meaning of *semiotic system*. Unfortunately, some researchers have taken the root *mode* out of the term *multimodality* (KRESS; VAN LEEUWEN, 1996, 2001; STÖCKL, 2004; ROYCE, 2007; BATEMAN, 2009; KESS, 2009; STEIN, 2009) and talk about, for example, "the graphic or visual mode" and "the verbal mode" of language or texts. Kress (2009) and Stein (2009) even state that, for example, the graphic mode is another type of mode like the oral or written modes. Technically speaking, the correct derivation would be to say "graphic or visual modality" and "verbal modality" or "graphic or visual semiotic system" and "verbal semiotic system".

With more precision, within Systemic-Functional Linguistics, the term *mode* has come to be used primarily to refer to the communication channel (e.g. written or oral) and not to refer to the type of semiotic system (e.g. verbal, graphic, mathematical or typographic). This distinction is crucial, as it is not focusing on the same concept or the same level of analysis. Thus, to keep not only a terminological separation but primarily a conceptual one, in our opinion, it is more precise to talk about *multisemiosis*, and *multisemiotic text*. In any case, it must be recognized that the term *multimodality* has reached widespread use, has gained importance and has formed its own area of study. The polysemy of this term is also not far removed from the term *modality*, which, perhaps unfortunately, in the literature of the specialty also has more than one technical meaning.

For the purpose of clarity and precision, in this article we will use the term *multisemiosis* or *multimodality* to refer to the organization of the various semiotic systems that make up a written static text. We reserve the term *mode* for the distinction between writing and speaking.

2.2.1 Written (multisemiotic) texts: What is a system or modality? and how many are there?

In this article, with a focus on disciplinary academic texts, we state that a "semiotic system" or "modality" consists of a collection or of a repertoire of signs of the same nature (e.g. verbal, graphic, mathematical, etc.) interrelatedly constructed based on functional, semantic or morphological organization principles within each system. In other words, a semiotic system simultaneously has a group of constituent units and a type of syntax that regulates them. These systems are also characterized by a specific order of the units, an order that is a form of conceptualization and meaning, thus making singular use of the space in the text. Concretely, in the case of the static written text, these systems are constructed to serve communicative purposes according to the needs of the writers, within a determined social and cultural context. In this sense, these systems or modalities can come out of different mediums of representations and can present various intra and intersemiotic relationships (STÖCKL, 2004; KONG, 2006; ROYCE, 2007; MATTHIESSEN, 2007; JEWITT, 2009; BEDNAREK; MARTIN, 2010).

Royce (2007) recognizes that not much work has been produced linking and explaining the nature of the intersemiotic semantic relationships between the verbal and visual or graphic systems. In particular, Royce (2007) puts emphasis on explaining the characteristics that make a text verbally-visually coherent. Royce (2007), along with some other researchers (e.g., BATEMAN, 2008; MARTIN; ROSE, 2008; BEDNAREK; MARTIN, 2010), proposes frameworks within discourse analysis to study multisemiotic texts. In our opinion, it is striking how the description of these multisemiotic text features crosses the line into the text's psycholinguistic processing between a speaker/writer and a listener/reader. In other words, it is interesting that in an exclusively descriptive analysis, based only on certain texts, connections can be made between one modality and another without empirically investigating the reader's effective discourse processing. This topic is highly relevant to the study of multisemiosis and intersemiotic relationships, as, in our opinion, there is a lack of psycholinguistic studies that could help understand how a reader establishes relationships between modalities and what type of links these are. Without a doubt, this emerging and scarcely explored niche is a growing space for research, and open to complementary investigation from both corpus-based studies and discourse comprehension research. In this line, Gries (2010, p. 333) proposes that Corpus Linguistics should be "a psycholinguistically informed, (cognitively inspired) usage-based linguistics"; at the same time but on a different argumentative direction, Parodi (2011) supports the idea that psycholinguistics should be a corpus-based interdiscipline and that Corpus Linguistics should inform research on discourse processing.

To discuss further our specific area of concern, the static written text within a group of disciplines, we start from the base that there are four semiotic systems or modalities that synergetically complement and interact to construct meaning through the text. These are the verbal system, graphic system, mathematical system, and typographic system (LEMKE, 1998, 2005; O'HALLORAN, 2004, 2005, 2008; VAN LEEUWEN, 2005, 2006; BEDNAREK; MARTIN, 2010). It is fundamental to establish that, although this

fourfold distinction is proposed, these four systems occur throughout genres and disciplinary texts, giving way to multiple artifacts in an indefinite list of emerging possibilities and thus constructing complex meanings.

Figure 1 shows this conception of the written text and its four constituent systems.

Figure 1 - Four semiotic systems in static written texts
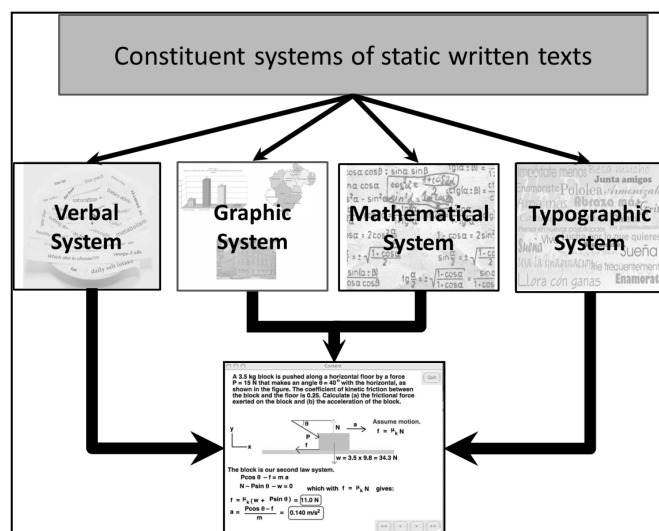
Source: Parodi (2010d).

The verbal system is composed of words and clauses that make up the expression of meaning based solely on the linguistic resources. In other words, the form of expression is the lexicogrammatical. Thus, there is a lexicon and a syntax that is singular in each language.

The graphic system is made up of strokes that form a pictorial representation of information of all kinds, which allows for the presentation of data in determined formats. This representation makes possible through graphic mediums the visual communication of processed and synthesized ideas, facts, and values, as well as social, cultural, economic, aesthetic and technological factors. Today, a large part of graphic design is aided by digital tools on the computer, a fact that has come to enrich the available possibilities and mediums. Photographs, graphics, diagrams, tables are typical resources of the graphic language, sometimes combining various modalities simultaneously. The use of blank spaces is also an important resource in the graphic system, as the appropriate balance of its use is part of the visual composition.

The mathematical system is composed of groups of signs or a variety of representations also called alphabet characters, which allow meaning to be symbolically encoded synthetically. The constituent elements of this system interact, based on one or various types of syntax. More precisely, this system is composed of numerals (Roman or Arabic), letters (Greek or Latin), operators and punctuation marks. Through the phylogenetic development of the human species, this system has not evolved to the point of achieving total autonomy, so it requires the verbal and typographic systems, among others, in its co-texts in order to construct an intersemiosis that includes the complete units of meaning trying to be communicated.

Lastly, the typographic system is made up of the form and color of the letters, which includes boldface, italics, upper case, lower case, color, dimensionality (one, two or three-dimensional), etc. The typographic meanings as part of the total meaning of the written text have possibly been the most forgotten and even linguists have paid little attention to them (VAN LEEUWEN, 2005, 2006). The typographic modality is not a simply decorative one, as it is not just a matter of visual aesthetics. Rather, through its diverse forms, this system gives a meaning potential that, along with other systems, can thus transmit the total meaning of the text. Originally, the typographic system could have emerged to fulfill an ornamental or decorative

purpose, but in its evolution human beings have taken it to fulfill a much more dynamic role. Actually, with the evolution of the computer processed texts, writers have become much more aware of the mediums at their disposal and the system has thus taken on a considerably more active role.

### 2.2.2 The concept of (multisemiotic) text

In our conception of written texts, the four semiotic systems described are constituent in its nature, although they may not all be present in a specific text. In other words, in the construction of meaning through texts, the four systems tend to come up jointly. With the illustration in Figure 1, the intention is not to propose that these systems predate the text itself, but rather that human beings have constructed and developed them over time to communicate through texts. They are inherent in written texts and in the meanings human beings have felt the need to express in specific contexts, which is to say, they fulfill a specific purpose. From this perspective, it is not exact to say, "the text and the figures", "the text and the images", or "the text and the multisemiotic artifacts". On the contrary, text exists as a complementary and integral unit, and in it the verbal, graphic, mathematical and typographic systems tend to synergetically interact. Consequently, depending on the meaning being communicated, there will be a predominance or appearance of certain systems over others; thus, it is possible that there will be texts in which all four systems are not necessarily present. In this line of argument, it is possible that, within linguistics, the hegemony of the study of the verbal system over the others has led to these expressions that, in our opinion, are erroneous and confusing. Therefore, it is important to specify the conception on which our research is based on and to separate it from these other perspectives which are less precise.

In this vein, it is also relevant to say that each one of these semiotic systems has both intrasemiotic and intersemiotic relationships, as is shown in Figure 2.

Figure 2 - The semiotic systems and their relationships.
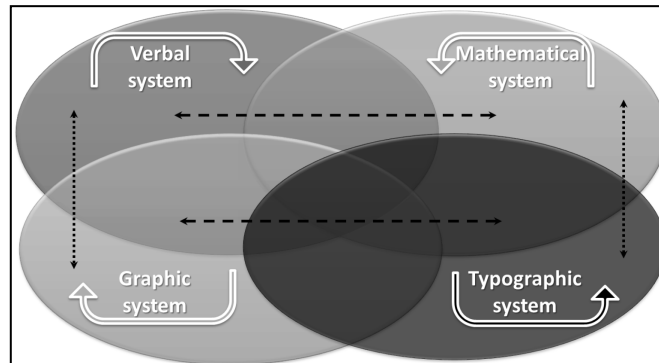
This figure shows, on one side, the close link between certain systems and, on the other, the complexity of separating one semiotic system and its resources from others. For example, when defining the mathematical system, though one could think of it as an autonomous system and that it would be very simple to separate it from the verbal, graphic and typographic, the empirical analysis of a particular text shows an intrinsic complexity. This is not a problem in and of itself, as what it does is to show the nature of the textual multimodality and the synergy of the interrelated systems. Actually, the mathematical system is partially supported by the verbal co-text and makes explicit use of the graphic and typographic systems. As an example of this point, we offer the following excerpt from a Chemistry text from the corpus under study:

(*)
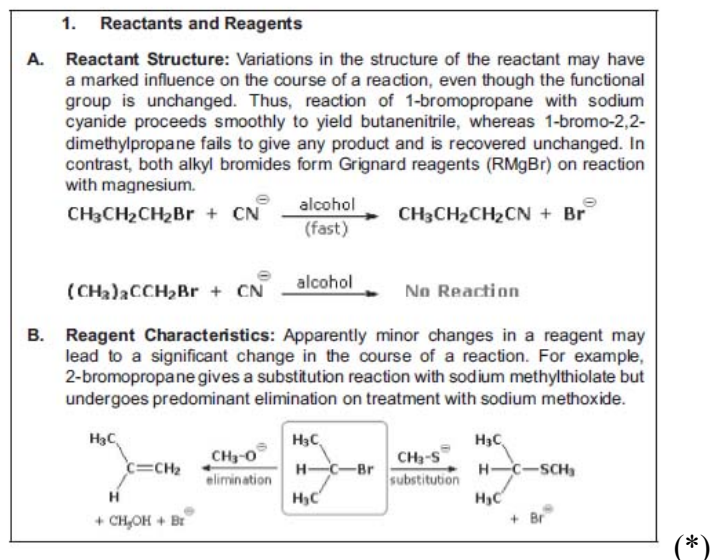
Based on this example, the aforementioned systems cannot be radically separated nor thought of as external to the text, except for methodological reasons, or as a consequence of research focus. The systems are deployed with various intra and intersemiotic relationships and together they give form to the units of meaning of this excerpt of a Chemistry text. What was discussed based on Figure 2 can also be clearly seen, where the intrasemiotic relationships are deployed within a system, as are the various possible intersemiotic links between two, three or four systems.

3 THE STUDY: CORPUS AND METHODS

3.1 Compiling the PUCV-2010 Academic Corpus

The PUCV-2010 Academic Corpus is made up of reading materials for doctoral students in the areas of Social Sciences and Humanities (SS&H) and Basic Sciences (BS). The corpus was collected in twelve doctoral programs (two for each specialty) in six Chilean universities and includes all of the documents registered as reading material in obligatory classes in the respective curricula, with the exception of those included in doctoral thesis research. Table 1 shows the six selected disciplines that make up the corpus under study.

Table 1 - Areas and disciplines selected

Scientific area	Discipline
Social Sciences and Humanities	History
	Linguistics
	Literature
Basic Sciences	Biotechnology
	Physics
	Chemistry

These disciplines were selected with the objective of getting a wide overview of possible variations of written documents in the respective doctoral programs. The initial procedure of collection and digitalization of the corpus in this part of the research has been relatively similar to what we have done in other previous investigations (PARODI, 2010b) and are summarized in the table below.

Table 2 - Collection and processing of the PUCV-2010 Corpus

Step 1: Create a database with the information on the universities that offer the six doctoral programs in Chile.
Step 2: Contact the directors of the selected programs in order to obtain the syllabi of all courses in the curriculum of each doctoral program.
Step 3: Create a database with the complete information of the doctoral programs' curriculum in the six specialties and the respective syllabi of each course.
Step 4: Create a database with all the obligatory and suggested bibliographical references, included in the syllabi.
Step 5: Conduct an Internet search to find the titles available in digital form, thus minimizing digitalization time.
Step 6: Collect the texts from the corresponding libraries and professors' offices.
Step 7: Train a team of assistants to compile and scan the texts.
Step 8: Process and convert all the corpus texts into editable PDF form and plain text form (*txt).
Step 9: Upload each text to the El Grial program (www.elgrial.cl) on the online platform along with its corresponding tagger and parser.

3.2 Makeup of the PUCV-2010 Academic Corpus and the sample under study

Based on steps 1-7 in the previous table, the total figures of the collected texts are shown in Table 3.

Table 3 - Numerical makeup of the PUCV-2010 Academic Corpus

Discipline		Texts by discipline	Totals
Social Sciences and Humanities	Linguistics	1,075	2,616 (82.8%)
	Literature	946	
	History	595	
Basic Sciences	Biotechnology	227	544 (17.2%)
	Physics	181	
	Chemistry	136	
Total		3,160 (100%)	

Given the size of the corpus and the time required to attain all of the material for the multisemiotic artifacts study, we decided to conduct a study with a random and proportional sample representing 33% of the total corpus. In Table 4 the numerical makeup of this study is shown, with the total corpus as a reference point.

Table 4 - Makeup of the sample under study

Disciplines	Total textos in the Corpus	Random and proporcional sample (33%)
Linguistics	1,075	355
Literature	946	312
History	595	196
Biotechnology	227	75
Physics	181	60
Chemistry	136	45
Total	**3,160 (100%)**	**1,043 (33%)**

An *ad hoc* computer program using a mathematical formula was employed for the selection of texts for the sample. This allowed for the random selection of the required number of texts based on the total list of each sub-corpus per scientific discipline. In this way we reached a sample of 1,043 texts, divided by discipline as shown in Table 4. As mentioned in the introduction, this study addresses academic discourse and its characterization as far as multisemiotic resources used within the six disciplines under study is concerned. In this phase of the investigation as already stated, the variation of multisemiotic artifacts across discourse genres is not discussed.

4 RESULTS

4.1 Identification and definition of the multisemiotic artifacts in the PUCV-2010 Academic Corpus

To identify the artifacts present in the sample of texts and get a rigorous count of the frequency of occurrence of each artifact in the texts of the six disciplines under study, a team of assistants was trained to manage the theoretical principles and operational criteria for their identification. After a phase of training and calibration of the criteria being used, the assistants were checked for strong performance in the identification and counting in a balanced and systemic manner. This was calculated with a test of training texts, in which a level of 96% of agreement with consultation to four experts was reached in interrater reliability.

Our focus in this first part of the study does not incorporate the research on the interactions between these four semiotic systems nor in which one system complements or "translates" into another (ROYCE, 2007; BATEMAN, 2008; MARTINEC; VAN LEEUWEN, 2009; O´HALLORAM; TAN; SMITH; PODLASOV, 2010). Based on the four semiotic systems already identified (Verbal, Graphic, Mathematical and Typographic), we identified nine multisemiotic artifacts in the sample of 1,043 texts in the PUCV-2010 Academic Corpus. We decided to use relatively common names that correspond to what we have traditionally used to refer to these artifacts. Perhaps the most novel artifact is what we have termed Compositional Web. These nine artifacts are listed in alphabetical order in Table 5.

It is worth pointing out that given the sample size, compared to the total corpus, it is very possible that in a future analysis of the rest of the texts new artifacts come out that were not observed in this study. Thus, the quantitative results given below should be taken as an exploratory step in the description of the PUCV-2010 Academic Corpus.

Table 5 – Identification of multisemiotic artifacts

Multisemiotic Artifacts PUCV-2010 Corpus
Diagram
Formula
Geometric Figure
Icon
Illustration
Map
Statistical Graph
Table

Each one of these artifacts represents a group, range or continuum of resources. We are starting from the supposition that these categories are not exclusively separate or distinct. Figures 3 and 4 show this principle based on the Diagram and Statistical Graph artifacts.

Figure 3 – Variation of the Diagram artifact
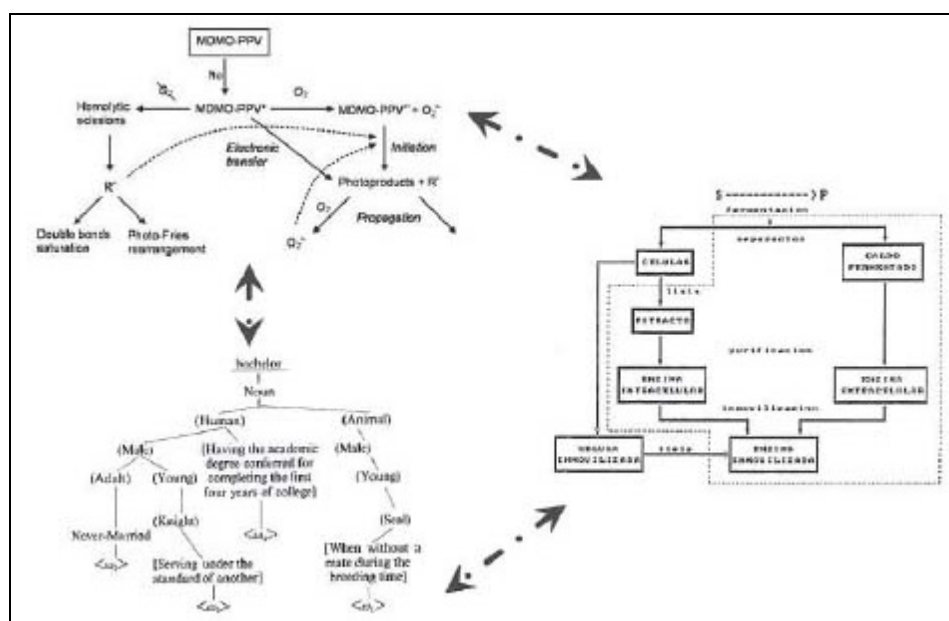
As can be seen, three types of diagrams are shown. All three fall within the Diagram category, but the variety shows the possibilities for more concrete cases. Some of them could be considered as more prototypical cases and others more borderline, but they all belong to the category termed Diagram.

A similar situation comes up in the Statistical Graph artifact, as seen in the examples in Figure 4.

Figure 4 – Variation of the Statistical Graph artifact
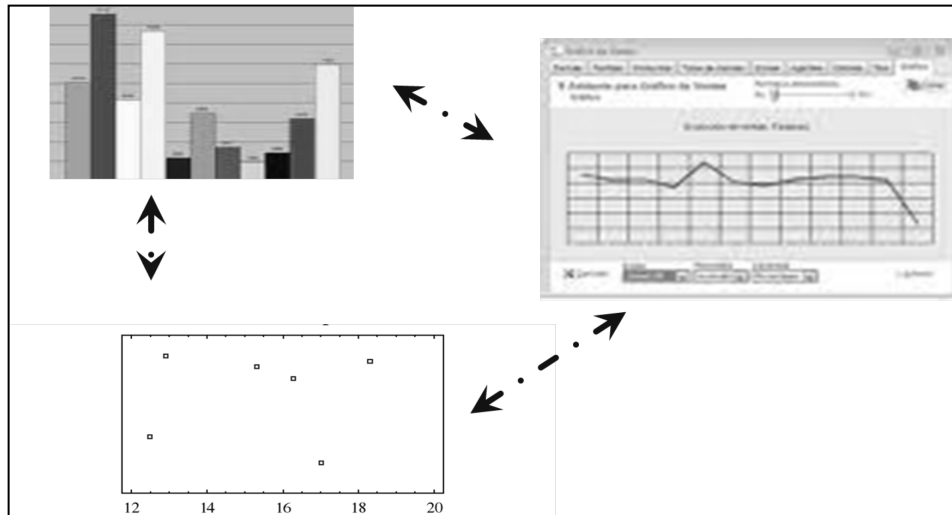
In order to more accurately determine each of these artifacts, we established a working definition, based in three criteria: modality, function and composition. In Table 6 the criteria and the question to guide the criteria are listed, which are included in the same order in each definition.

Table 6 – Criteria used in the construction of the definitions

Criterion 1	Criterion 2	Criterion 3
Modality (What systems are involved in the artifact?)	**Function** (What is the artifact used for?)	**Composition** (What does the artifact consist of?)

In the following section we will give a definition and example of each multisemiotic artifact, with examples taken from the PUCV-2010 Academic Corpus. These are summed up in Table 7.

Table 7 – Definition and example of the nine multisemiotic artifacts

1. Diagram: artifact that combines the verbal, graphic and typographic modalities. This representation of meaning synthetically shows a theoretical or empirical construction, and generally sums up the hierarchical organization and link between parts and components or a determined object or concept. Diagrams can be made up of squares, functional or related operators (e.g. arrows, brackets, braces, etc.), bullets, numbering, size and type of font (e.g. upper case and lower case, boldface and italics) and colors.


BIO16   LIN1.268

2. Geometrical Figure: artifact that primarily uses the graphic system, although to a lesser degree also uses the verbal, typographic and mathematical systems. It is, for the most part, the representation of a space enclosed by lines that shows an object or theoretical concept. Its main components are: the plane, the point, the line (straight, curved, dotted), the surface and the segment. Through variations and movements of the components, different lines, surfaces and volumes are created. Thus, they can be one or multidimensional (two-dimensional, three-dimensional). The most common geometrical figures are: squares, rectangles, circles, pyramids and polygons.
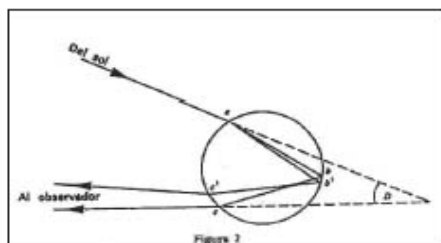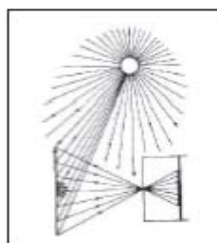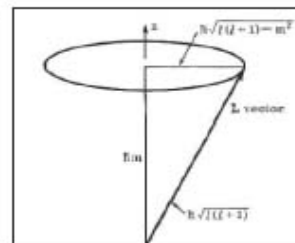
LIT3   LIT183   FIS109

3. Formula: artifact primarily based on three modalities —mathematical, verbal and typographic. The formula permits the expression of information in a succinct way, relating quantities, constants or variables. It includes a list of characters, organized with a syntax and based on one or various alphabets. This representation can include Roman or Arabic numerals, Greek or Latin letters (upper case or lower case), operators (functions) and punctuation marks. Typography comes into play through the use of boldface and upper case letters, etc.

$$\int \mathbf{F} \cdot ds = m \int \frac{d\mathbf{v}}{dt} \cdot \mathbf{v}\, dt = \frac{m}{2} \int \frac{d}{dt}(v^2)\, dt,$$
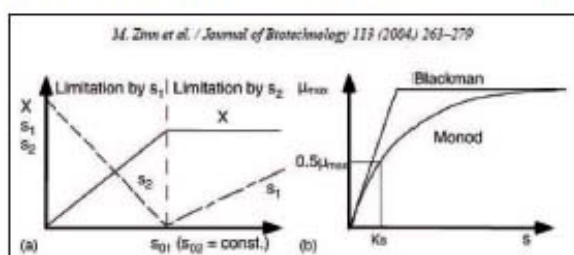
FIS127

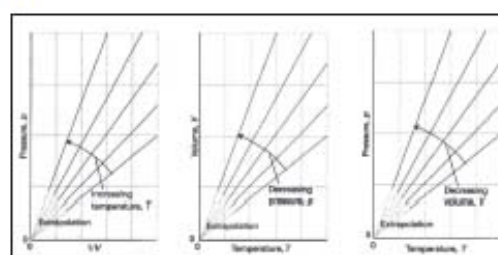$$|\vec{F}| = \frac{|q_1 q_2|}{r^2}.$$

FIS108

$$\lim_{n \to \infty} \left(1 + \frac{1}{n}\right)^n \quad y \quad \sum_{n=0}^{\infty} \frac{1}{n!}$$

LIN1.035

4. Statistical Graph: artifact that primarily combines the four modalities: verbal, graphic, mathematical and typographic. It pictorially represents a visual summary of statistical information. The statistical graphs can be line graphs, bar graphs, pie graphs, histograms, etc.

BIO25   QUI49

5. Icon: artifact that is primarily constructed based solely on the graphic modality. It tends to represent or substitute a real or ideal object, and be very similar to an object in the real world. It also quickly and easily represents an ideal, empirical or associated concept, as in for example, computer science (e.g. a program, function, document, file or folder). Traditionally they are flat (one dimensional) figures or illustrations, but currently they can also be multidimensional.
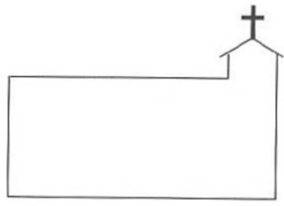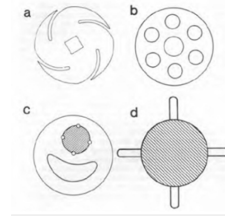
LIN1.180   QUI49   BIO53

6. Illustration: artifact that primarily uses the graphic modality, although to a lesser degree also uses the verbal and typographic. It mainly represents real or ideal objects, through photographs, drawings, prints and engravings. It tends to decorate or complement, either in black and white or in color, another part of the text that is usually verbal. It is made up of free strokes or oftentimes a piece of reality is captured in a direct or exact way, allowing for its recording and reproduction. In this way, the illustration can fairly precisely record circumstances, phenomena, states or events, traditionally in one dimension though today it can also be multidimensional.

Fachada del Club Naval, Valparaíso

HIS301   HIS7

7. Map: artifact that primarily uses one modality – the graphic system. However, it can also utilize the verbal and mathematical systems. The map is a geographic representation of one part or the entire surface of the Earth, in which location, and physical and social phenomena can be shown. There are physical maps, geographical maps, world maps, static and dynamic maps, etc.

HIS268   HIS606

8. Compositional Web: artifact that often combines the four modalities –verbal, graphic, mathematical and typographic. It synthetically represents a variety of information in an original presentation, given that it primarily corresponds to nonlinear complex compositions emerging out of the new digital mediums (e.g. screenshots of web sites). Its composition can be hierarchical structures particularly prototypical of the four constituent semiotic systems.

QUI49   LIT609

9. Table: artifact that predominantly combines the verbal, graphic and typographic systems, although it often uses the mathematical system as well. The table tends to represent hierarchical contents and classifies and defines specific information. It also provides summarized quantitative and qualitative results and data in a dot matrix format.


LIN1.268   HIS193

4.2 General comparisons

Figure 5 shows the percentage distribution of the frequency of total occurrence of the nine artifacts based on the 1,043 texts analyzed. In Figure 5, the six disciplines are treated collectively.

The high percentage frequency of the Formula artifact is very striking. In this sample of the total of multisemiotic artifacts identified, 72.9% correspond to an artifact that is primarily composed of a mathematical semiotic system, with secondary support form the verbal, graphic and typographic systems. This finding of such a strong presence of the Formula artifact supports an accurate preliminary description of the specialized academic discourse at the doctoral level. It is very likely to hypothesize that the frequency of this artifact does not occur homogenously throughout all the texts in the sample, in particular within the six disciplines under study. In the following analysis and figures, we will provide further information to clarify this matter.

Figure 5 – Percentage distribution of the artifacts in the sample of texts
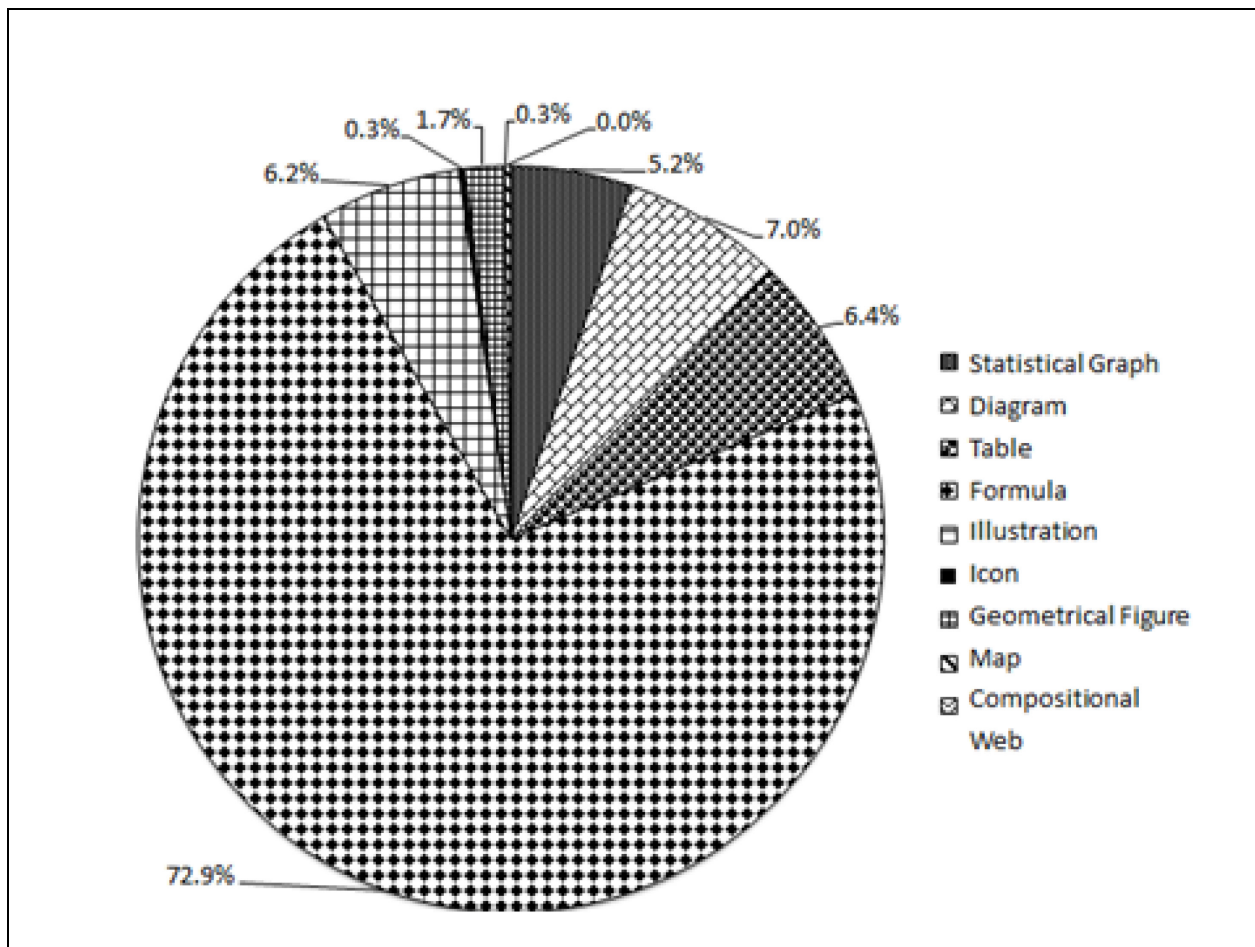
Far behind the Formula in percentage of frequency, the Diagram (7%), Table (6.4%), the Illustration (6.2%) and the Statistical Graph (5.2%) are the next four artifacts that appear in the total sample. On the one hand, the tremendous statistical difference between the frequency of the Formula and the other four artifacts is a significant finding that shows the importance of the Formula in academic discourse at the doctoral level. It is clear that, through the Formula and the corresponding intersemiotic relationships with the other systems, specialized units of meaning are constructed that represent a large part of the reading material of university students in higher education. On the other hand, it is also interesting to note the singular homogeneity in the percentages of frequency in the other eight artifacts mentioned: two distinctive groups can be identified (one close to 5 or 6% and another close to 1 or 2%). The limited participation in academic discourse, within the study, of the Map, Geometric Figure, Compositional Web and Icon is evident. Their mere identification is a relevant scientific finding, however the low figures are very informative on how meaning construction and transmission take place in academic discourse.

We now move on to a deeper study of the occurrence of artifacts in the sample texts, but now separating Social Sciences and Humanities and Basic Sciences (Figure 6).

This data is certainly very revealing and clearly positions the Formula in a unique place within the texts in the sample and the disciplines as a semiotic resource that is prototypical of the Basic Sciences (BS). It is also present in the texts of the Social Sciences and Humanities (SS&H), though, as can be seen, to a much lower degree (3.47%). However, it is without a doubt a substantive finding as its presence in the disciplinary discourse decidedly marks some of the disciplines under study. In the 545 texts that make up the BS sample, a total of exactly 100,124 (96,53%) formulas were identified, while in the 2,616 texts in the SS&H sample there were 3,602 formulas. The number of texts is comparatively much larger in the SS&H;

however, it is clear that this multisemiotic artifact is not prototypical of the academic discourse in these disciplines.

Figure 6 - Frequency occurrence of the artifacts in the sample of texts
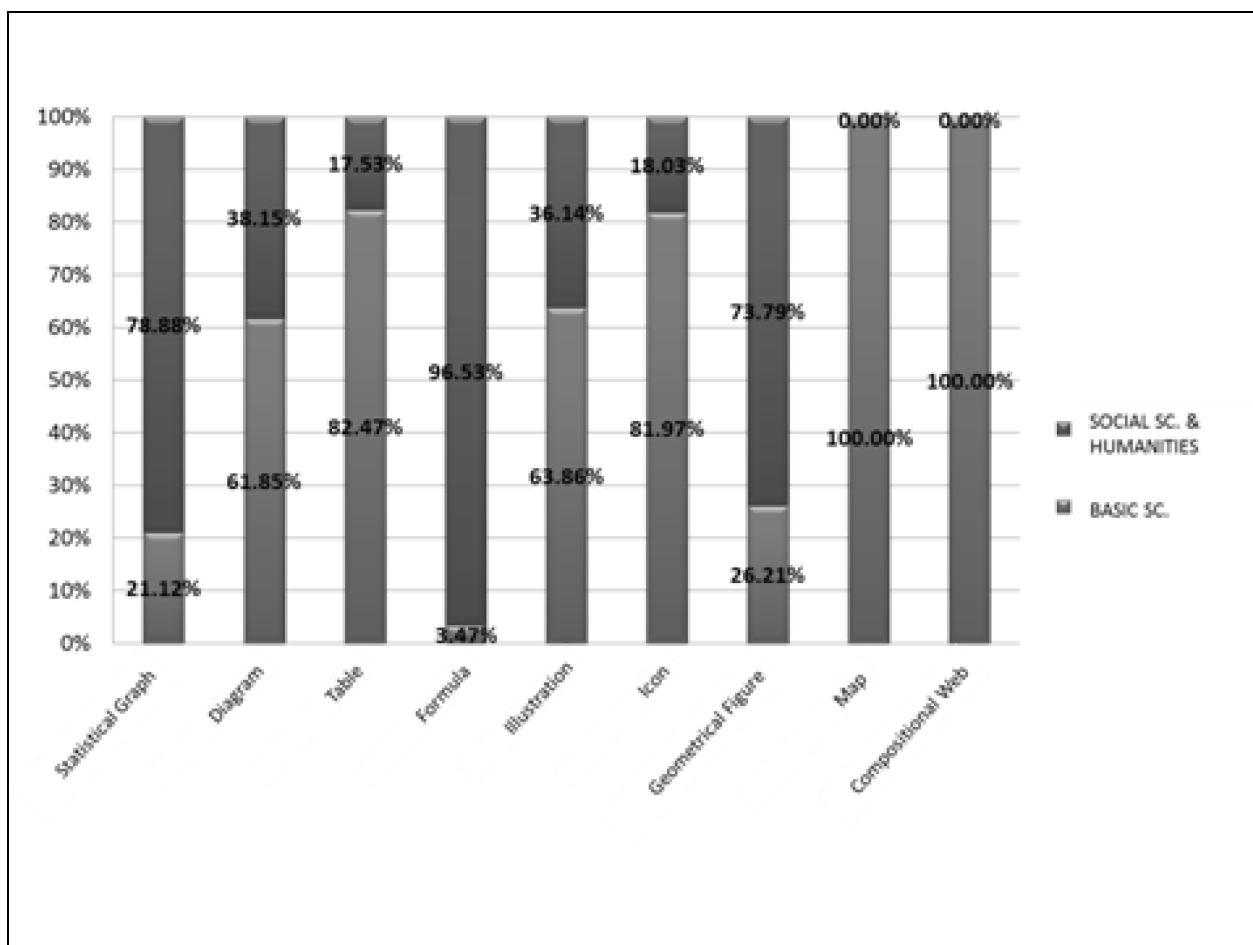
As shown in Figure 6, the Map and the Compositional Web appear exclusively in the SS&H, unlike the other seven artifacts that, with various levels of frequency, appear in both disciplinary domains. It should also be pointed out that the Table (82.47%), the Icon (81.97), the Illustration (63.86%), and the Diagram (61.85%) all have a percentage of frequency of above 60%, compared to the figures in BS. These findings, in a very preliminary description of the written discourse of the SS&H, illustrate the strong tendencies which show the way disciplinary meanings are constructed and the way in which a wide range of multisemiotic devices are employed. These artifacts and their relatively homogenous frequency show the most prototypical traits of the SS&H texts, to which students of higher education would have to access and through which they should learn to comprehend academic content, learn its discourse genres and construct mental dynamic representations.

These figures also reiterate the strong presence of the Formula in the texts of the BS. However, there is a frequency of 3.47% within the SS&H, which indicates that its use, though limited, supports the construction of determined multisemiotic textual units of meaning. The Statistical Graph (78.88%) and the Geometric Figure (73.78%) along with the Formula give form to an overview of the multisemiotic artifacts most characteristic of the BS, based on the data obtained from the sample of 545 texts.

4.3 Some results from the disciplinary texts

In this section we will review the frequency of occurrence of the artifacts, but now presented in each one of the disciplines under study. Figure 7 provides this information.

Figure 7 – Percentage distribution of the artifacts in the texts of each discipline
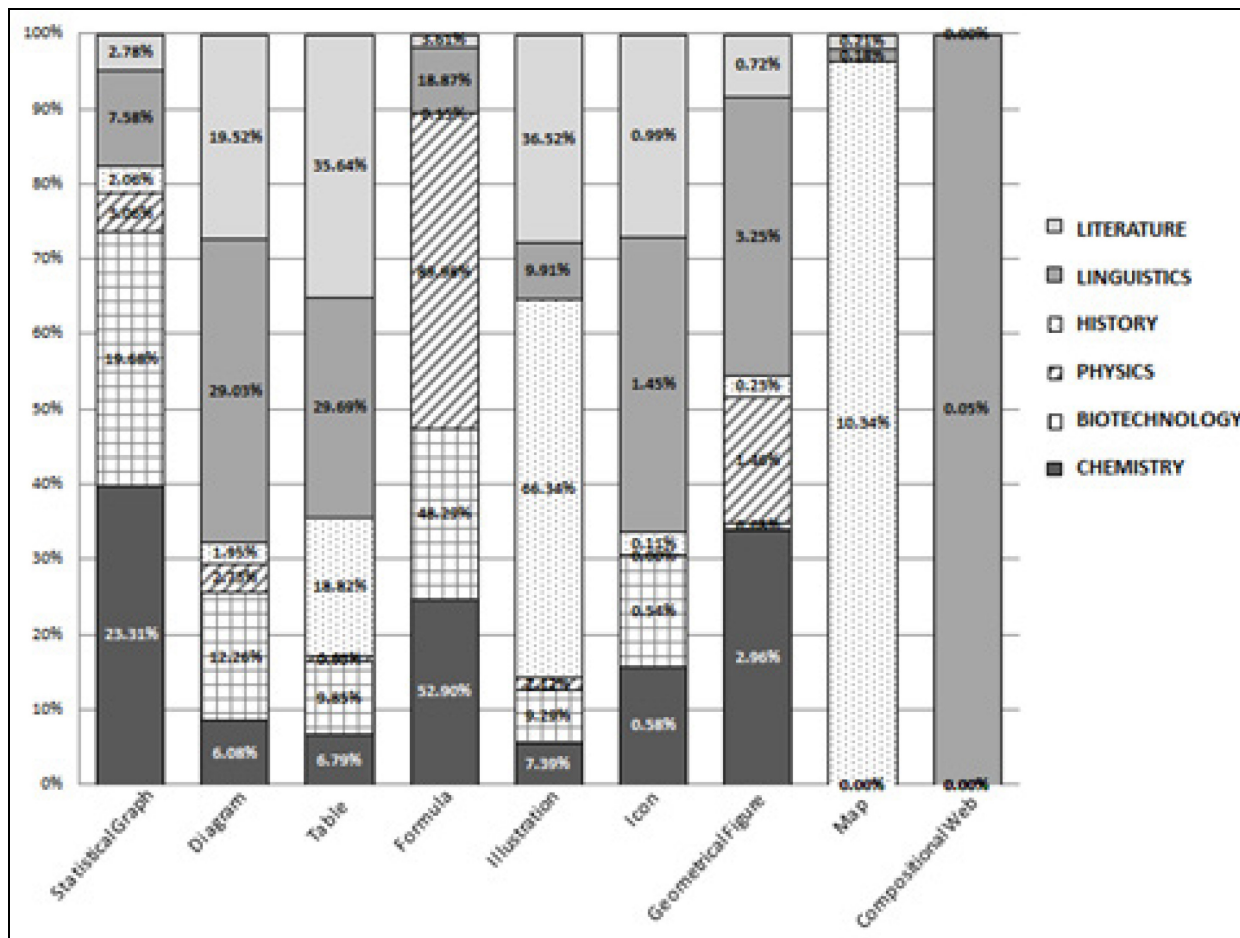
Given this data, it is clear that the Formula with its high frequency in the sample is primarily concentrated in Physics texts. Of the total frequency in the sample of texts, 89.98% was identified in the 181 Physics texts. Comparatively speaking, the rest of the occurrences, to a much lesser degree, were found in Chemistry (52.9%), Biotechnology (48,2%), Linguistics (18.8%) and Literature (3,6%). Figure 7 also shows that in the Physics texts, along with an extremely high frequency of the Formula, there is also a significant appearance of five other artifacts: Statistical Graph (3.1%), Diagram (2.7%), Illustration (2.1%), Geometric Figure (1.4%) and Table (0.6%). Together, this empirical data gives Physics academic discourse a particular characterization and shows its highly multisemiotic nature (six of the nine artifacts identified in the corpus), particularly compared to the other five disciplinary texts. This is to say that the makeup of the discourse of Physics has complex intersemiotic relationships among the verbal, graphic, mathematical and typographic systems. It also displays the highest frequency of a multisemiotic artifact present in the texts (Formula: 89.9%).

In the same Figure 7, we see that the nine multisemiotic artifacts appear altogether in the texts of only one discipline: Linguistics. Though with a much lower frequency than in Physics, in the Linguistics texts sample there is a wide and diverse repertoire of multisemiotic resources. On the opposite extreme is History, in which only three multisemiotic artifacts are identified (Map, Illustration and Table).

A word of caution is fundamental here. The percentages permit the comparison of frequency of the artifacts in the texts of the disciplines; however they do not show the real occurrence in the sample's texts. For example, in the case of the History texts, the Map has a frequency percentage of 89.63%, and in the Linguistics texts, the Compositional Web has a 100% frequency. However, in History 353 Maps were identified, and in Linguistics 8 Compositional Webs were found. There is no doubt of the effectiveness of descriptive statistics through percentages, but a look at the gross figures is also necessary.

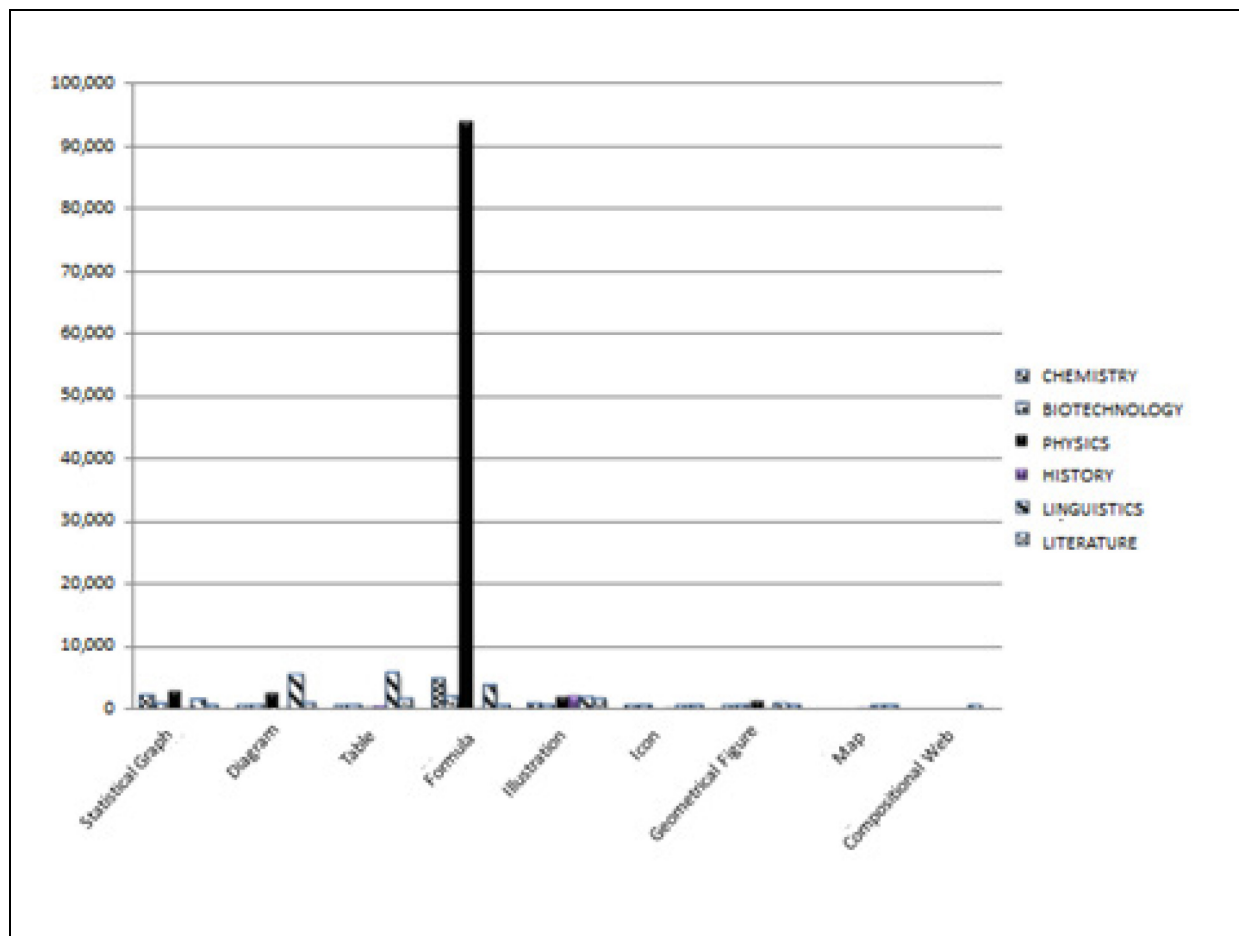Figure 8 – Gross frequency per artifact and discipline

Figure 8, in part, shows the extremely high number formulae in the Physics' texts (a figure close to 95,000), compared to the other eight artifacts and the rest of the five disciplines. The presence of the Formula in the Physics' texts, as has already been pointed out, reveals an interesting pattern in the description of these disciplinary texts, one that displays an intricate discourse organization in a very distant point from any other artifact and discipline. This means, among other things, that the verbal system is evidently not the most important means of construction and transmission of meaning in this disciplinary discourse, but a different way of knowledge construction and access is identified. Evidently, the multisemiotic features of Physics' text are totally different to a History's, Literature's or Linguistics' texts in which the verbal system is by contrast the most important.

Second in the number of artifacts are Chemistry's texts. Important number of diagrams, tables, formulae and illustrations are present in the texts of this discipline. Nevertheless, no comparison can be made with the exceptionally highest occurrence of Formula in Physics.

Based on these findings, constructing knowledge for a new student to a disciplinary discourse such as the one in Physics implies coming across textual features and also developing and acquiring cognitive strategies which surely are quite different compared to the same student approaching a Literature's text. In order to produce a deeper analysis into this data, we present in the next section the quantitative results from a different perspective.

4.4 Average frequency of artifacts per discipline and per page

To provide a more specific panorama of the multisemiotic disciplinary discourse, based on the total number of pages in the sample's texts, we calculated the frequency of occurrence of each artifact per page of each document. The results, grouped by artifact, are displayed in the following figure.

Figure 9 – Frequency of each artifact per page in the six disciplines
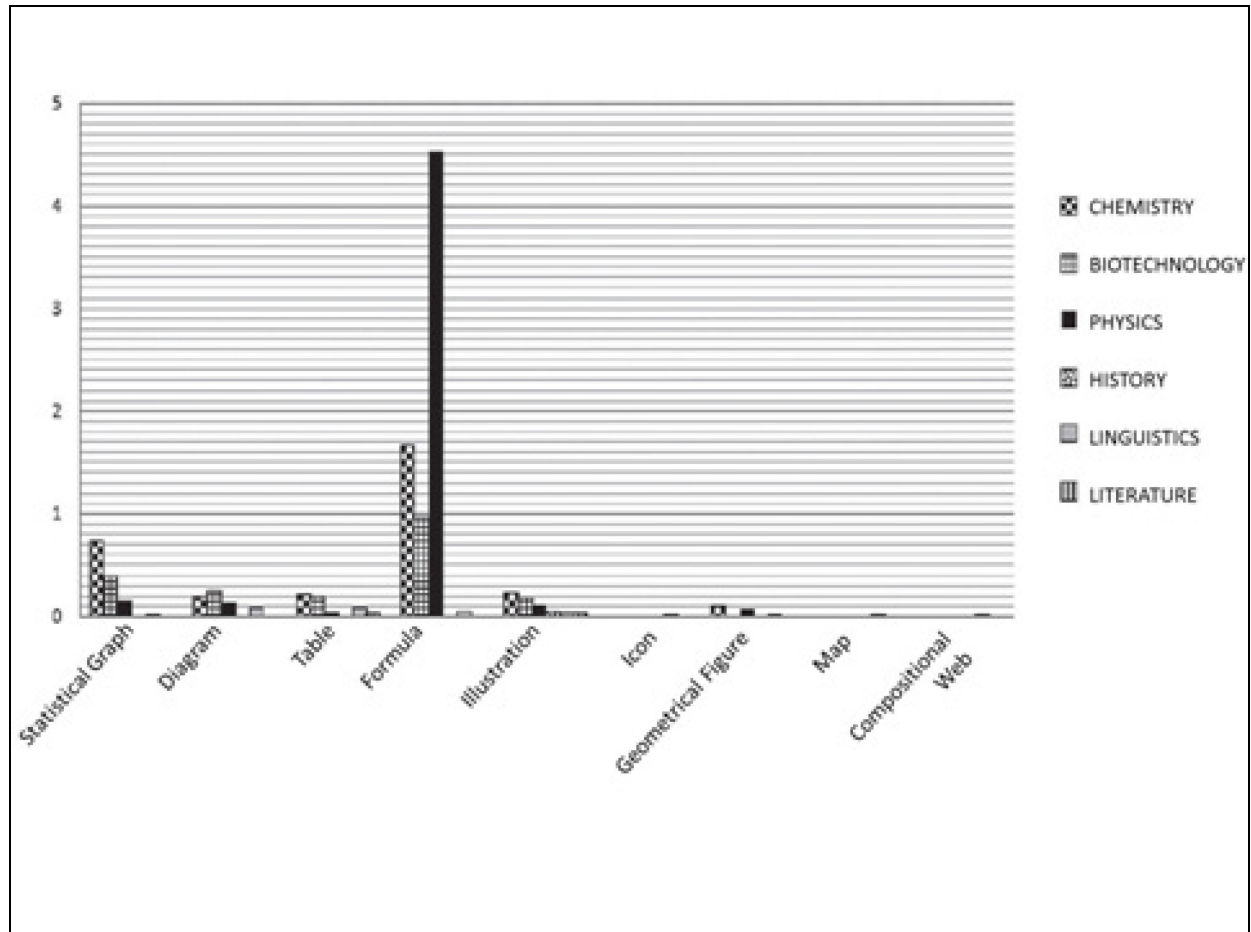
This data corroborates what we have been pointing out regarding the unique makeup of the Physics discourse. As can be seen in Figure 9, one page of a Physics text shows a high average frequency of a significant number of artifacts (4.5 per page). A similar situation occurs, proportionately on a lower scale, on one page of a Chemistry text and one page of a Biotechnology text. Considering all the six disciplines, the most prominent feature is clearly the high frequency of formulae per page. Nevertheless, a clear complementarity of statistical graphs, diagrams, tables and illustrations accompanies the important presence of formulae, not only in Physics but also in Chemistry, Biotechnology and Linguistics. In comparison, one page of a text in the disciplines of the SS&H shows a very different makeup, clearly more inclined to the verbal system than to the others.

This empirical data confirms what laypeople or scientists may hypothesize speculatively about the texts of these disciplines, in terms of the discourse of the BS compared to the SS&H. The important point here is the scientific confirmation and what the empirical findings have clearly revealed. In this case, we corroborated what we expected, as in the descriptive phase of the frequency of multisemiotic artifacts, BS texts showed a higher concentration of a wide variety of average artifacts per page in the sample of texts. This descriptive finding must not be confused with the idea that this type of discourse, due to its multisemiotic configuration, is necessarily more complex to process and comprehend. This is a separate matter to be investigated and psycholinguistic researchers should undertake this work. The link between a higher presence of diverse multisemiotic artifacts on one page of text and its level of complexity to process and the degree of comprehension, memory and learning involved constitute an emerging area of investigation, based on the data given here.

Another way of looking at this same data is exclusively within the disciplines and considering the average of the group of artifacts that are registered on one page of the texts. Figure 10 shows these average figures.

Figure 10 – Frequency of artifacts per page in each discipline
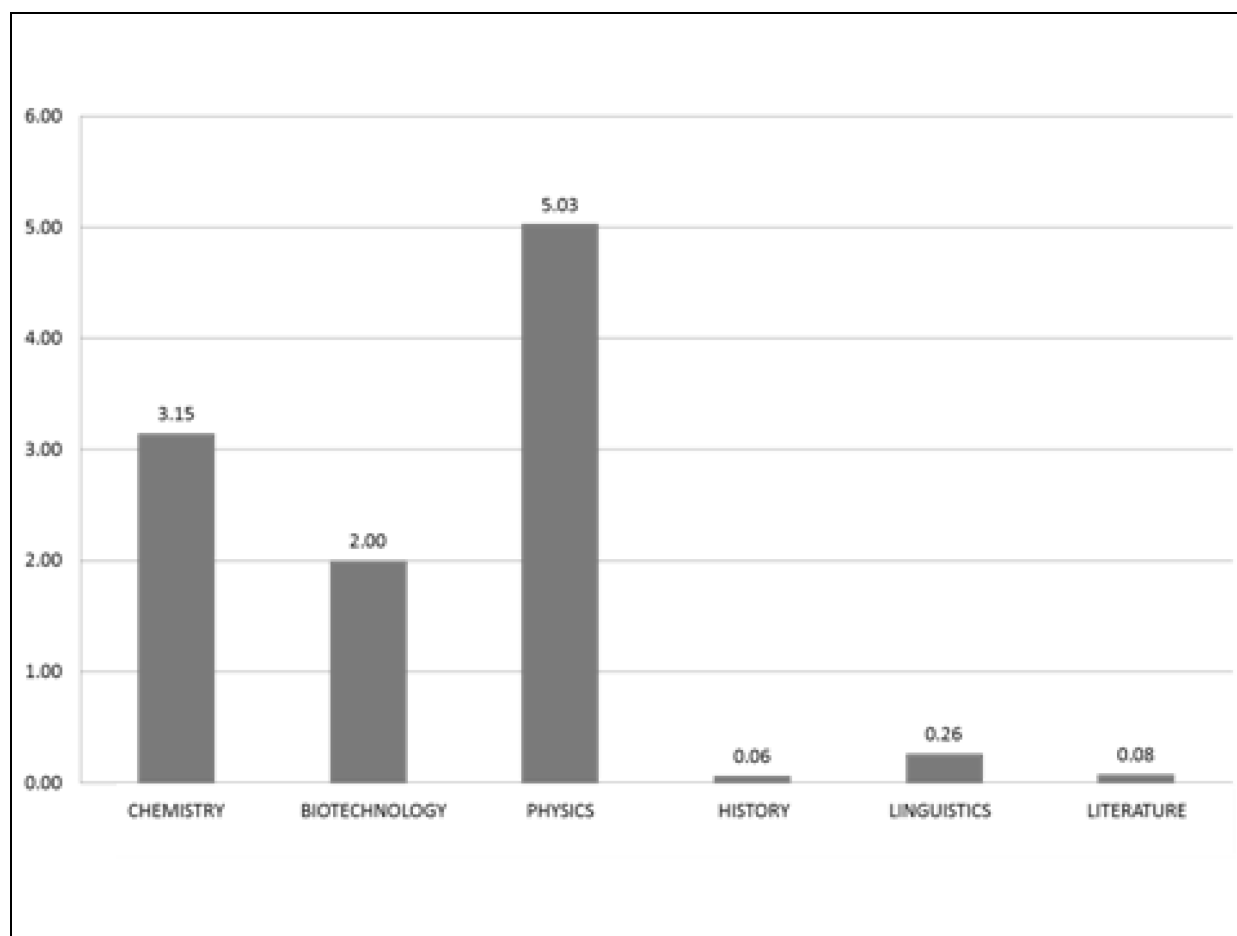
These figures again show that one page in these six disciplines offers a variety of complexities in terms of the presence of multisemiotic artifacts. It is clear that disciplinary discourse is not made up of words and typographic variations alone, but rather in some disciplines more than five artifacts on average can be detected per page. This indicates that in some cases it is possible to find a much higher concentration of these artifacts, as the normalized figures certainly do not imply total homogeneity. Indeed, there will be pages of Physics (5.03 average artifacts per page) and Chemistry (3.15 average artifacts per page) texts that will show much higher frequencies than those in Figure 10. These figures also show the strikingly high difference between the nature of the discourse of the SS&H and the BS, in terms of multisemiotic constitution. In the same way, the variation detected across disciplinary discourse is also remarkable. The high presence of average artifacts per page in Linguistics (0.26 average artifacts per page) is clearly different from the texts of the other two SS&H disciplines unlike the more predominantly verbal nature of the texts in Literature (0.08 average artifacts per page) and in History (0.06 average artifacts per page).

5 DISCUSSION

The findings reported here clearly distinguish between a more predominantly graphic-mathematical-oriented disciplinary discourse (Physics, Chemistry and Biotechnology) and a more verbal-typographic-oriented one (History, Literature and Linguistics). This multisemiotic disciplinary variation is portrayed in Figure11.

Figure 11 - Disciplinary discourse according to textual composition
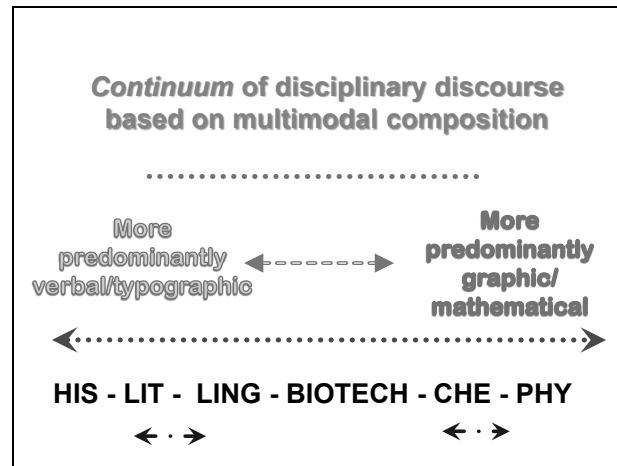
From the empirically collected data, the findings allow for the alignment of the sample's texts of these six disciplines in a continuum from the most predominantly verbal to the most prototypically graphic-mathematical. The discourse of Physics and that of History are at the two extremes of the continuum. According to the data gathered, the texts in Linguistics and Biotechnology are in an intermediate position. Interestingly, the two share similar multisemiotic features.

The textual composition and its respective construction of multisemiotic units of meaning lead to a reflection on the configuration of the disciplinary textual spaces and the composition of the artifacts themselves. The selection of the resources in the static written texts is done within the disciplines both in the creation of the multisemiotic artifacts as well as in the definitive construction of specialized texts. What is being discussed here is if the specialists of the disciplines, knowing the various resources available, have opted for certain ones because they are aware of the meaning that this type of particular knowledge communicates, or because this type of communication cannot be conveyed through other semiotic systems. This is to say, the scientists in Physics must obligatorily use the artifacts that have become their only method of constructing written units of meaning, and the History scientists have preferred to mainly convey meaning through the verbal system, because this adjusts to the nature of their discipline.

Lemke (1998) had already brought attention to the diversity and high concentration of artifacts, based on an analysis on a group of Physics and Medicine texts in English. Based on articles taken from prestigious scientific journals and chapters of books, Lemke (1998) preliminarily established an average frequency of between three and six artifacts per page, depending on the discourse genre. To do so, he started from an a priori classification and differentiates graphs, equations and tables. Interestingly, though he used a corpus carefully chosen in disciplines and genres and of a very much smaller size in comparison to ours, his results point to similar findings.

6 CLOSING REMARKS

The approach to the data, perhaps in a more ecological perspective, based on complete texts collected in ecological contexts and with empirical "corpus-based" methodology, allowed us to identify various semiotic systems interacting complementarily in order to construct and transmit meaning through disciplinary discourse in academic environments at the doctoral level. Nevertheless, no emphasis on the language of the texts involved was taken into account in this study, since we are not concerned –at this point of the research- with whether they were written in Spanish or English (the two languages identified in the corpus). However, it is worth noting that a considerable number of the material analyzed in some

disciplines such as Physics, Chemistry and Linguistics was originally written in English, which gives information on a second language read in doctoral programs in Chilean universities.

As has been empirically demonstrated throughout this article, specialized knowledge is communicated through various semiotic systems, which is configured in a particular way in each discipline. In this vein, disciplinary texts are irreducibly and essentially of a multisemiotic nature, but with important variations across disciplines; therefore, an interesting continuum was detected with the texts of Physics on the one extreme and the texts of History on the other.

The data analyzed has also revealed that the construction of specialized concepts is done through interrelated units of meaning with a base in a variety of complex modalities that include, among others, the verbal, graphic, mathematical and typographic. Thus, the supporting data in this study reveals, based on a sample of 1,043 texts in six disciplines, that to produce and communicate specialized knowledge different canonical systems are combined. Based on these four systems, it was possible to identify nine multisemiotic artifacts: Compositional Web, Diagram, Formula, Geometric Figure, Icon, Illustration, Map, Statistical Graph, and Table.

The empirical findings reported in this study, based on a random and proportional sample representing 33% of the total corpus, provide an overview of the specialized academic discourse of the texts in the six scientific disciplines of which there is no previous record in Spanish language or in any other. This study is unique in the empirical robustness of the ecologically collected data in everyday contexts and in the framework of nationally accredited doctoral programs, in public and traditional Chilean universities.

These types of findings allow for the appropriate construction of informed opinions. These opinions can help in making curriculum change decisions, guide innovation in educational policies, regulate the creation of performance standards and generate guidelines for linguistic planning in diverse contexts. More specifically, this data also aids curricular decisions regarding academic and professional literacies within the disciplines and the development of specialized reading and writing abilities. This is all within the framework of the construction, access, development and transmission of disciplinary knowledge.

The study of multisemiotic artifacts within the disciplines by discourse genre is yet to be conducted. This other perspective will provide fundamental information to learn more about the features of disciplinary discourse. Our proposal of four semiotic systems (verbal, graphic, mathematical and typographic) will also have to be reviewed and possibly expanded on with new empirical data. It is also likely that the identification of artifacts will need to be extended to the 3,160 total number of texts in the PUCV-2010 Academic Corpus. This preliminary study could be just showing one part of the tremendous variety of multisemiotic artifacts present in the other texts in the corpus. Also, the possible variation depending on the language in use, whether Spanish or English, is another challenge to be faced in future research.

Lastly, another future challenge is the investigation in the psycholinguistic processing of multisemiotic texts in various disciplines and its possible level of complexity in creating mental representations that show the meaning process of construction using various semiotic systems. At this time, we have already started some research in this area, of which we hope to report soon.

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