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**English for Science and Technology: Technical texts  
for academic purposes**

Summary of PhD Thesis

**PhD researcher: Sonia Carmen Munteanu**

**Coordinator: Prof. Univ. Dr. Ştefan Oltean**

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## Introduction and organization

Discourse analysis takes as its object of study language in use and, in so doing, incorporates a twofold orientation: towards action and towards *interaction*. Because in using language there is no action without *interaction*, analysis of discourse must consider both. For professional communication, language is one of the components that facilitate the reaching of specific goals. Acknowledging that there are linguistic resources (lexical, grammatical, rhetorical, and functional) among which users may choose some and ignore others, in order to achieve their communicative goals in professional practice, studies have referred to this discourse as ‘language for specific purposes’. The *who*, *why*, *where*, *when* and *what for* all play a part in the action and interaction language for specific purposes displays. Within this scope, the present research sets out to investigate English for Science and Technology.

The paper has two parts with converging aims. **Part one** is built around the need to define EST as an object of linguistic study and follows a diachronic development of the meanings the term EST has acquired. I start from a rather general foundation where recurring terms and concepts are introduced (**A general framework for analyzing discourse**). *Discourse*, *variation*, *context*, *structure* and *text* are discussed as they will be often used throughout the study with the connotations presented. Terminological considerations are extended to section II (**Variants of language in use. Terminology**), in order to set our object of study within and among other sections of linguistic investigation. The terms *English for Specific Purposes*, *English for Academic Purposes* and *English for Science and Technology* are defined.

I proceed further to a more in depth investigation of the features of EST as they have been revealed by various approaches taken to study it. I will show that the *profile* and *specific characteristics of EST* are not easily identifiable, and that EST as an object of systematic linguistic inquiry has slowly emerged from studies that often only tangentially referred to it. Thus, approaches as different as general discourse analysis, systemic functional linguistics, genre studies, (foreign) language teaching, ESP studies, corpus linguistics, or sociolinguistics brought important contributions to profiling EST. All these contributions are reviewed in section III (**EST as an object**

**of study**) with a focus on relevant elements for the present study. A summary of this first part is provided in IV.

**Part two** narrows the scope and focus of the research to written texts on science and engineering topics for academic purposes and claims a more personal contribution as it is mainly based on close analysis of authentic texts. From a general discussion of the research in science and technology and the language used to carry it out (**EST in the academia**), the study identifies and defines those parameters along which discourse variation occurs in relationship with scientific research. These are *discourse community* (V.2), and *discipline specific discourse* (V.3) articulated in what is called a *research space* (V.4). As this is a text-based case study, a discipline is selected from engineering fields (Mechatronics) and undergoes an ethnographic investigation (V.5) to establish social relevance from within its own community. The aim of this part is to establish that, within broader E(A)ST discourse, there is disciplinary variation, observable along parameters such as *formulation of knowledge claims, authorial stance and voice* (VI.1 **Knowledge claims and the interpersonal function**) or *textual characteristics of rhetorical general patterns* such as (sub)genres of research articles (VI.2. **Generic forms in support of discipline specific discourse**).

The paper ends with a conclusions section and a series of observations indicating further lines of investigation of EST for discourse studies, ESP studies as well as language teaching.

## **Part one: Language in use and variation in language use**

This part has as main focus a review of terms and concepts related to language in use and variation. Starting from a wider perspective of discourse as language in use, context, structure and text as pillars of discourse understanding, attention is turned towards a narrower functional perspective of variation in language use. Three important concepts are reviewed and defined here:

- ESP/LSP refers to domain related discourses and its study looks into aspects of communication in specialized fields such as science, medicine, law, environment, etc. A discourse oriented approach is taken to analyze domain specific communication based mainly on factors such as the degree of specialization of text, the relationships between the communication participants, the degree of expertise knowledge they have and the purposes pursued by them.
- EAP is seen in the context of languages for specific purposes; attention is given to the branch labeled English for specific academic purposes (Jordan 1997). Here a challenge to traditional views on characteristic features of academic prose is presented. We conclude that modern academic prose is better described as *condensed* and *compressed*, that its grammatical complexity lies mostly in the *structure of the nominal phrase* and that it is semantically *less explicit* as understanding of specialized meaning depends heavily on specialized knowledge.
- EST is the language used in the professional contexts of natural sciences and technology.

In the following section, EST is discussed as an object of study for various discourse approaches. The review follows analysis of the discourse of science from comprehensive discourse analysis theories, through genre theory, register variation and cognitive approaches to variation inside frameworks of analyzing specialized discourse. The aim is to provide an overview of outcomes relevant to a profile of (domain specific) specialized discourse and of outcomes as new directions/relevant frameworks for more specific levels of investigation into specialized discourse.

The first approach is L.Trimble's (1985) who states that EST is a spectrum/continuum extending from the peer writing of scientists and technically oriented professionals to the writing aimed at skilled technicians. It includes several types of instructional

discourse, with various communicative purposes and targeted audiences. It is the first comprehensive view on the discourse of science and technology as a distinct variant of language in use.

In the Systemic Functional framework the focus is ‘the language of science’ seen as a functional variety or ‘register’. One crucial aspect in the evolution of scientific discourse is the need to construct technical taxonomies. This particular cognitive and communicative act was realized in the English language by regular morphological patterns for representing a classificatory system in words. Recognizable resources of scientific discourse are nominalizations, high lexical density, nominal style and grammatical metaphor.

The language of science is viewed in genre studies in the context of professional communication. Studying professional communication and its genres is motivated by:

- a. the fact that written disciplinary communication is meant to facilitate social interaction and the production of knowledge;
- b. the fact that the production of knowledge is codified in generic forms.

Two traditions are overviewed here: Swales’ Create a Research Space model (1990, 2004) and Bhatia’s professional genres perspective (2004). Genre studies relate professional communication as patterned responses with professional practices and communities producing the respective genres. They introduce the idea of variability within patterns and disciplinary variation in language use. An extension of this genre theory is the social/cognitive genre approach, where social and cognitive are complementary categories and complete a detailed and comprehensive view of discourse and textual features of genres (Bruce 2005).

Corpus based approaches provide another interesting view on languages for specific purposes and on the language of science in the same context. Corpus based studies draw statistical data from large population of texts. They allow comparisons with many text-variables and contextual variables. An important outcome for the study of disciplinary communication is their stress on parameters of similitude and variation, not as individual features but as patterns of co-occurrence. These approaches support increasingly more specific levels of analysis. Comparative studies show that the ‘register’ of science varies on several dimensions from, for example, conversation (Biber et al 1998). Multi-dimensional analysis proved useful in studying more specific



registers and in identifying what makes them different from one another (e.g. research articles in ecology vs. research articles in history).

Lexical approaches to EST are related mostly to (foreign) language teaching and learning. Computer aided research and language corpora offer opportunities to look at specific 'technical' vocabulary beyond single words in any field. Data driven research has indicated that specialized lexis is better thought of as language prefabs or 'formulaic multi-word units/collocations' (Mudraya 2006). Thus, technical vocabulary comprises words and collocations specific to one or closely related fields, with high frequency, specific meaning and typical collocation patterns.

The studies reviewed here by no means exhaust the work done on the language of science and technology. This has not been my purpose as it would be beyond the scope of my own studies oriented mainly towards research settings and EAP in science and technology. They however provide both a panoramic view on a rather intuitive concept, that of English for science and technology, and a close-up on sections of language in science-related contexts. Each approach supplies valuable insights into its lexical-grammatical profile, historical evolution, rhetorical structures and situational characteristics. The written mode has been favoured. It appears that these close-ups on narrower sections, on discipline specific language, provide more detailed characteristics and reveal the degree of inter-dependency between linguistic characteristics and situational factors such as the communicative needs of the discipline, its diachronic evolution, its discourse community or its genres.

## **Part two: EST in the academia. A text-driven case-study of disciplinary academic discourse**

A genre approach to science disciplines in academic contexts is taken in this part. The focus is on *prototypicality* and *variation*, as well as *on factors that favour variation*: the nature of the discipline and its practices and discourse community. To highlight the way they contribute to disciplinary variation in language use I propose a case study of types of texts in six academic journals from humanities and engineering. The most frequently published text is the research article, confirming its prominent status in academic professional communication (Swales 1990). Other conclusions can be drawn from the data presented:

- Discourse in science and technology fields evolves alongside the disciplinary knowledge and acquires individuality when the needs and practices of the respective communities require particular forms of communication.
- There is a clear relationship between, on the one hand, the disciplines and their professional/academic communities (including writers, editors, reviewers, audience) and, on the other hand, the communities and the (written) forms of communication their disciplinary practice promote.
- More consistent and regulated forms depend on the maturity of the discipline and coagulation of its community.

Specialized discourse is the focus of the next section. It is seen as variation of choice due to particular purposes, subject matter, audience, disciplinary practices. A theory of specialized discourse can develop within a theory of specialized knowledge. A theory of specialized discourse needs to combine a theory of specialized texts with one of specialized contexts (van Dijk 2003). For ESAP the context is a ‘research space’ whose elements include: the community and the relationships among its members (including the issue of membership), the discipline, its specialized (generic) discourse forms, contextual constraints that impede upon their production and reception, the (written) means of communication, particularly scholarly journals.

In order to investigate the particular research space of science disciplines and their professional academic discourse I turn first towards the way knowledge is built in science fields. Knowledge claims are expressed and proved in hard sciences in

published academic texts; knowledge claims are expressed in different ways in different disciplines and this modulation leads to **disciplinary specificity of discourse**. The purpose is to see whether the author and the audience as members of disciplinary community interact in science academic texts and whether this ‘dialogue’ influences the linguistic, functional and rhetorical features of the texts analyzed.

The interpersonal function is thus targeted in the case studies meant to outline disciplinary features of specialized discourse. The interpersonal function has writer and reader- oriented components. Writer oriented components (elements of personal expression):

- Hedges and attitude markers;
- Boosters;
- Self-mention.

Reader oriented components (elements of reader engagement):

- Directives
- Knowledge reference.

For the case studies Mechatronics, an engineering discipline, is taken as focus. The investigated parameters are:

- Modulation of knowledge claims;
- The interpersonal function (writer and reader oriented components);
- Generic forms as elements of disciplinary specificity: titles and abstracts as genre-sets.

RAs from online professional journals in Mechatronics were chosen in order to establish the profile of the discourse community, the social relevance of the discipline and its most relevant practices (questionnaires and survey). Text-analyses were performed, followed by comparison with data from other hard sciences investigated along similar parameters and with comparable methods.

The corpus of the case study focusing on modulation of claims and the interpersonal function comprised approximately 20,000 words of RAs published in two journals in Mechatronics. The statistical data are displayed below both in comparison with previous studies and as original statistics:

<b>Device</b>	<b>Epistemic modal auxiliary</b>	<b>Semi-auxiliary</b>	<b>Lexical vbs with epistemic meaning</b>	<b>Epistemic adverbs and adjectives</b>	<b>Approximators Adjectives/adverbs</b>	<b>Intensifiers (boosters)</b>	<b>Self-mention</b>
<b>Examples</b>	can be steered can be regarded can be approximated can define may be very... may not know may be written must be know should be defined should exceed will be reduced could result could be integrated	seem be	proposes showing it is shown shown in ... fig 8 shows illustrated in is depicted (we) demonstrated does not imply implies suppose	possibly possible hardly	generally in general some quite usually most almost frequently nearly mainly	inevitably very successfully clearly much certainly well greatly (varying) perfectly always absolutely simply thoroughly	we ( <i>multiple authors reference</i> ) we ( <i>inclusive only in conclusion remarks</i> ) our ( <i>once</i> )

Table 4: Hedging, boosting and self mention as writer-oriented strategy

<i>Author</i>	<i>Discipline</i>	<i>Average per paper</i>	<i>% of all citations</i>	<i>Total no.</i>
Hyland (2001)	Mechanical Engineering	3.7	10.6	-
	Electrical Engineering	3.8	9.3	-
	Physics	2.8	11.0	-
	Biology	10.8	11.8	-
Martinez (2008)	Biology	8.1	24.9	49
My corpus	Mechatronics	2.6	11.6	16

This case analysis has sought to show how writers of RAs in an engineering field modify their knowledge claims in order to achieve their overall communicative purpose, that of proving hypothesis and turning them into disciplinary knowledge. The interplay of hedging and boosting devices reveals an authorial voice whose presence, though often challenged by the need for objective and impersonal presentation of data, is pervasive all through the text. Use of specific features to express tentativeness, fuzziness but also certainty and strength of expert abilities is similar to findings of other studies taken here as referential frameworks. What a close inspection of texts, within well defined theoretical frameworks for analysis can do, is generate quality insights into discourse resources, on the one hand, and contextual and disciplinary factors, on the other hand, which generate (disciplinary) variation in language use.

The second case study takes as its object generic forms and tries to show how structural and functional patterns may be considered factors of disciplinary variation.

The corpora analyzed are from the same professional journals in Mechatronics mentioned before. Their composition is displayed below:

<i>Journal</i>	<i>year</i>	<i>vol./issue</i>	<i>no. of selected RA titles per issue</i>
<i>Mechatronics</i>	1991	1/1	9
		1/2	8
		1/3	7
		1/4	10
	2001	11/1	1
	2005	15/4	2
	2008	18/1	1
	2009	19/7	15
		19/8	11
	2010	20/1	16
	20/2	14	
<i>IEEE/ASME Transactions on Mechatronics</i>	2010	15/3	15
<i>IEEE/ASME Transactions on Electronics</i>	2010	57/5	2
<i>The Journal of Micro-Nano Mechatronics</i>	2008	4/1-4	16
	2009	5/1-4	9
<b>TOTAL</b>			<b>136 TITLES</b>

Table 6: Titles corpus

<i>Journal</i>	<i>Vol/year</i>	<i>Issue</i>	<i>No of abstracts analyzed</i>
<i>Mechatronics</i>	<i>vol 1/1991</i>	issue 1	2 abstracts
		issue 2	2 abstracts
		issue 3	1 abstract
		issue 4	1 abstract
	<i>vol</i>	issue 1	5 abstracts
	<i>20/2010</i>	issue 2	1 abstract
<i>Journal of Micro-Nano Mechatronics</i>	<i>Vol 5/2009</i>	Issues	3 abstracts
		1	
	<i>Vol 6/2010</i>	Issue 1	1 abstract
<i>IEEE/ASME Transactions on Mechatronics</i>	<i>Vol 5/2000</i>	Issue 1	1 abstract
	<i>Vol 11/2006</i>	Issue 2	1 abstract
	<i>Vol 15/2010</i>	Issue 3	2 abstracts
<b>TOTAL</b>			<b>20 ABSTRACTS</b>

Table 7: Abstracts corpus

The study of titles in the field of Mechatronics starts from the assumption that in a compact and concise form, titles serve the specific needs of a research community in specific ways, performing pragmatic functions derived from those needs and making meaningful choices with regard to syntactic structure or vocabulary choices. Titles are, thus, not only indicative of such needs but also setting the coordinates of discipline specific discourse.

The abstracts are investigated employing existing frameworks, namely the IMRC/D format (Bhatia 1993) as well as the functional move analysis (Swales 1990 and 2004) of the CARS model.

Results show that titles only use two of the known title structures in academic professional discourse: noun phrase titles and compound title structure. Full sentence titles are absent from this discipline and are seen as a meaningful absence. Also, diachronically, a tendency has been observed towards more informative and more compact titles in the RAs of Mechatronics. This rhetorical evolution is in line with that of the body of knowledge of this engineering discipline.

In the rhetorical analysis of abstracts, a typical move/step pattern has been observed:

<i>Moves</i>	<i>Steps</i>	<i>Frequency in %</i>
<i>Move 1 Introduction</i>	Step a ‘making topic generalizations’	35
	Step b ‘indicating gap/problem in the field’	60
	Step c ‘claiming centrality’	20
	Step d ‘announcing present research’/’announcing key result’	95
<i>Move 2 Methods</i>	‘outlining method’	90
<i>Move 3 Results</i>	‘announcing principal findings’	100
<i>Move 4 Conclusion</i>	Step a ‘evaluating results’	75
	Step b ‘stating value/implication of present research’	25

Table 8. Rhetorical structure of abstracts in Mechatronics RAs

This structure is a selection of moves and steps observed by Swales (2004) in all academic RAs of various disciplines which reflects the communicative needs of the discourse community under scrutiny here. Only steps with a higher frequency than 60% were considered obligatory. Interesting results were obtained in the case of move 1 step d, realized by formulaic language of the type '*text+verb+object*' where often the 'object' slot coincides with the noun phrase in the title. This particular choice confirms the assumption that titles and abstracts converge in meaning and structure towards a common aim: being as informative and as concise in expression as possible. Another possible disciplinary feature is the presence of Methods move in 90% of all abstracts analyzed on this discipline. The fact that Methods tends to disappear as an integral part of abstracts in the RAs of other sciences/engineering sciences and thus is not indicated as an obligatory addition in the guidelines for authors, suggests that its presence is supported by a specific communicative need of this engineering discourse community, one that is yet on the way of formulating analytic tools and methodologies.



## **Conclusions and further lines of investigation**

In the past half century substantial effort has been made to study and understand how language is used in specific contexts, for specific purposes and in particular interactional situations. The path of languages for specific purposes has been opened by pedagogically driven studies in the learning and teaching of foreign languages, but many and more interesting insights have been gained about *how language is used* for specific purposes beyond pedagogical interests. Varied approaches have brought their contribution: discourse analysis, corpus linguistics or socio-cognitive linguistics.

The object of the present research is English for Science and Technology, defined and described within languages for specific purposes. The first part has set to review approaches that contributed to understanding the language used in science and technology related contexts.

Disciplinary variation was traced to the specific communicative needs, connected to the activities involved, the discourse community and its specialized knowledge, its values and beliefs. Thus, disciplinary specific discourse can be said to stem from the nature of the specialized knowledge (van Dijk 2003) and the community that generates it.

Part two of the research has focused on discussing discipline specific discourse, taking a text-driven case-based approach. The analyzed texts belong to an engineering discipline, Mechatronics, whose profile, discipline community and practices have been presented. An ethnographic perspective was taken to this transdisciplinary engineering field, to establish its social relevance from the point of view of its community. The method employed was that of a questionnaire survey, paralleled by an overview of the literature that deals with definitions of Mechatronics as an engineering field, its position among other engineering fields, as well as the profile of its discourse community. The results point to the innovative character of Mechatronics research, its orientation towards practical results and product development, towards new methods of enquiry and development of such products. The community is made mostly of experts in engineering research and practice, and most of their communication targets the same level of expertise and not the general

public. Therefore, new information is mostly disseminated via professional academic journals.

The results of the ethnographic survey informed the case studies from *Part two* of the present research. In line with the findings, three corpora of research articles were compiled (full articles, titles and abstracts) that complied with the following relevant criteria:

- the research articles should belong, diachronically, to the first and latest published journal issues, so that evolution of disciplinary discourse could be observed;
- the research articles should be peer-reviewed prior to publication in journals with the highest relevance for the discipline (where possible with Impact Factor);
- the research articles should reflect the international character of the community and have authors of various backgrounds.

In the first case study the discipline specific discourse features identified in studies of science academic prose (Hyland 1997, 2006 among others) were discussed along two lines of expression: presentation of knowledge claims – the central focus of academic discourse – and authorial voice. A corpus of around 20,000 words was selected from two academic journals according to the criteria above. In a combined qualitative (clause-by-clause) and quantitative (frequency) analysis, expression of modification of knowledge claims and of authorial voice were identified and interpreted in the broader context of academic texts in hard sciences. The aim of the investigation was to show how knowledge claims were made, constructed and, ultimately, offered as important contributions to the specialized knowledge of the discipline. Hedges, boosters and self-mention were identified as expressions of authorial voice in modulating claims. Although traditional views considered the academic discourse of science as being impersonal and objective, the use of such modulators revealed a ‘vocal’ authorial presence. The conclusion these data indicate, is that they **articulate the interpersonal function, most sensitive to disciplinary variation**. My texts displayed reader oriented features, writer oriented features, modification of claims and citation and self-citation patterns **that are clearly linked to disciplinary practices disciplinary community aspirations**. They are all grounds for observing disciplinary

variation in the discourse of science and technology. The reader engagement strategy was observed in the use of directives. They realized both *textual acts*, instructing the reader to consult the reference material or parts of the text, and *cognitive acts*, instructing the reader how to interpret some facts or information. In this corpus, cognitive acts were mostly realized by structures of the type ‘*it is+adjective+cognitive verb*’, another possibly discipline specific feature.

The practice of (self-) citations is also clearly related to disciplinary practices. It was observed in the same corpus, that, unlike in other hard sciences, integral citations were not equally distributed throughout the whole article. They were present only in the *Introduction*, functionally related to the section dedicated to literature review. Non-integral citations were present in the more rhetorically charged sections of *Methods* and *Results*, but as mere numbers referring to positions in the bibliographical list. This situation indicates little intertextual dialogue and a non-polemical view on previous achievement in the discipline. Even where reference to other authors’ theories was made by integral citations, there was no evaluation of the cited theory. Previous work was taken in as support for further development and never critically assessed. This discursive strategy can be explained by the incremental nature of knowledge construction in Mechatronics, which is a new, developing field, where, for the time being, conflicting theories are scarce.

The study of disciplinary discourse features turned to titles and abstracts of research articles in the same discipline. Titles and abstracts are part of the interpersonal function as they represent the interface between the author and its potential audience. They have been taken as a *genre-set* with clear interdependencies pointing towards discipline specific discourse features. These were: **preference** for noun phrases and compound noun titles to maximize *informativeness* and **a particular selection of moves/steps** in the abstract construction to achieve the same level of *informativeness*. This second case study was based on two corpora. The title corpus was made of 136 titles of research articles in four academic journals in Mechatronics, from 1991 to 2010. The abstracts corpus comprised 20 abstracts in three of the same journals, extending over the same period of time.

In the case of titles, an evolution in the length of wording was observed, attributed to the ever growing body of knowledge, sharper selection of audience which, consequently, led to a pressing need for informativeness and conciseness in the structures used as titles. Although previous research on academic article titles showed that there are three structures used with different frequencies in various disciplines, my corpus displayed only two: *noun-phrase titles* and *compound titles*. The absence of full sentence title structure in Mechatronics was meaningful for a field with transdisciplinary roots and growing research opened to refinement. A full sentence title would show too much confidence where scholarly modesty and acceptance of alternative interpretations would be more valuable. *Noun phrase* titles were the most frequent choice (almost 90% of all titles), indicating informativeness and conciseness as the main rhetorical concerns. The construction of prepositional post-modifiers was interpreted as an expression of the practical and methodological orientation of this engineering field.

*Compound* title structure signaled case studies in most instances, and were seen as a straightforward linear construction of general theory applied to a practical situation.

Abstracts were functionally and structurally investigated and a move/step pattern was synthesized. Of the moves/steps identified, only those with a higher frequency than 50% were considered compulsory in the research articles of Mechatronics. An element of disciplinary specificity has been identified in the **emphasis** on the *Methods* move, present in 90% of the abstracts studied, and with substantial detail.

Another element of disciplinary specificity appeared in the use of formulaic language in *Step d* of Move 1, '*Announcing present research*', where the *text+verb+object* formula was realized with a limited range of words. Also, the slot '*object*' often repeated the title noun-phrase. Thus, with functional and rhetorical resources specific to each genre, titles and abstracts jointly construct a highly informative, compact and explicit - for the selected audience – interface between the text and its target audience.

Connecting discipline profile, discipline community knowledge and values and detailed text analysis, this study offers a basis for identifying elements of discipline

specific discourse, parameters of variation and methods of inquiry. It is along these lines that further work in studying disciplinary variation can be done.

Although it is beyond the scope of the present research, it is important to mention that valuable pedagogical implications lie in understanding disciplinary variation. Close textual inspection and principled methods of analysis such as those suggested in my paper can constitute premises of academic science discourse teaching, of learning it and of designing language teaching material. Awareness of variation, as well as of patterns contributes to better understanding of how language is used in professional and academic settings. Statistical and qualitative data from text analysis in various fields can provide teachers and users of English for Science and Technology a more detailed picture of a dynamic and heterogeneous discourse.

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